

POLICY INTERVENTIONS IN INDIA TO IMPROVE COASTAL RISK REDUCTION IN
THE FACE OF CLIMATE CHANGE

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A Thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Science

University of Washington

2020

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Abstract

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Coastal zones are one of the most dynamic natural ecosystems of our planet. The survival and livelihoods of coastal communities are contingent on the ecosystem services that coastal zones provide. Primary among these services is the reduction of coastal risks through the attenuation/dissipation of wave energy, breaking of offshore waves, slowing of inland water transfer and sediment stabilization. These functions protect people and infrastructure from coastal risks like tsunamis, storm surges, high wind and wave velocity, and other such extreme events. There is increasing evidence that coastal ecosystems including marshes, mangroves, near-shore coral reefs, seagrass beds, and sandy beaches and dunes provide the critical service of coastal risk reduction. Coastal systems and low-lying areas will increasingly experience adverse impacts brought on by climate change such as submergence, coastal flooding, and coastal erosion due to relative sea-level rise. Changes in storm intensity, high wind and wave velocity and storm surges may further contribute to an increase in the hazards faced by coastal communities. My analysis showed that the threats faced by the states on the eastern coast of India are very high and the

copying capacity of these states is low. This would exacerbate the impact of extreme events, brought on by climate change, in these states. Further, geospatial analysis shows that natural coastal ecosystems have declined over the last two decades and urbanization has occurred at a very fast pace, at the expense of these natural ecosystems. Coastal population has also increased, further increasing the exposure to coastal risks. Using DPSIR as a framework, I analyzed two policies relevant to coastal risk reduction and climate change, the National Action Plan on Climate Change (2008) and the Coastal Regulation Zone (2019). My analysis showed that these policies do not sufficiently identify and address the climate drivers and the pressures that coastal ecosystems face. They also do not fully identify the state of the ecosystem or address the pressures. The response needs augmenting as zoning allows for too many exemptions and permissions, identification and mapping of important areas of concern have not been completely carried out, and clear goals have not been set. The measures do not adequately address threats and do not contain objective criteria for assessment. Further, outcome indicators have also not been defined. While data illustrates the fact that coastal risks have increased due to urbanization and loss of natural cover, sufficient measures have not been put in place to address these. Based on the shortcomings and lacunae in the capacity of the analyzed policies to address threats to coastal areas, I have proposed a number of modifications in these policies. Most of these recommendations relate to the inclusion of an ecosystem perspective in these policies. There is also a need to take a science based approach to policy making which would make these policies more responsive to the increasing threats to coastal risk reduction in the light of climate change. Inclusion of measures to address climate drivers, pressures, impacts and threats would better position these policies in conserving the coastal ecosystems and enhance their capacity for risk reduction.

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Acknowledgements

I would like to thank the faculty and staff at University of Washington, School of Environmental and Forest Sciences. I would also like to thank my advisor and committee chair, Josh Lawler for his immense patience and guidance. I am grateful for the invaluable direction and advice provided by Mary Ruckelshaus and Dr Clare Ryan, which helped shape this thesis. My thanks also to USIEF and IIE who supported me during a difficult times. I am also thankful for the help provided by fellow Fulbrighter, Aditya Sharma for the GIS mapping. I am grateful to Sarah and Yian for the joyfulness and support they provided, especially when the pandemic put us under so much of stress and worry. I am also grateful for all the help provided by Michelle and Liz at Graduate Programme Advising.

I remain indebted to my friends and family members for their invaluable encouragement. Finally, this thesis would not have been possible without the support of my parents and sister who helped me get back to my feet and made sure that I remained healthy.

Introduction

Coastal areas comprise some of the most dynamic natural ecosystems of our planet, where three main components—the hydrosphere, the lithosphere, and the atmosphere—meet and interact, forming interconnected systems¹. Coastal ecosystems provide many ecosystem services that ensure the quality of life of people living in close proximity to the coast². Ecosystem services are the benefits provided by ecosystems that sustain and fulfil human life³. They have also been conceptualized as nature's contribution to people⁴. More than 600 million people (around 10 % of the world's population) live in coastal areas that are less than 10 m above sea level; nearly 2.4 billion people (about 40 % of the world's population) live within 100 km of the coast and are dependent on the ecosystem services provided by coastal areas⁵. The livelihoods and survival of coastal communities are contingent on the ecosystem service of coastal risk reduction that coastal ecosystems make available⁶.

There is increasing evidence that coastal ecosystems including marshes, mangroves, near-shore coral reefs, seagrass beds, and sandy beaches and dunes provide the critical ecosystem service of coastal risk reduction⁷. Coastal ecosystems can reduce risks to coastal populations by providing protection against storms and coastal floods—primarily through their capacity to attenuate waves⁸, buffer winds⁹, dissipate wave energy¹⁰, break offshore waves,¹¹ and slow inland water transfer¹². On average, coastal habitats reduce wave heights between 35 % and 71 %, coral reefs by 70 %, salt-marshes by 72 %, mangroves by 31 %, and seagrass/kelp beds by 36 %¹³. Mangroves can reduce the height of wind and swell waves between 13 % and 66 % over 100 m of mangroves, or 50 % and 100 % over 500 m of mangroves¹⁴. Storm surge peak water levels have been shown to be reduced by 5 to 50 centimeters by mangrove forest extending one km inland¹⁵.

Anthropogenically driven global climate change is increasingly impacting coastal risk reduction provided by coastal ecosystems. The effects of climate change include sea-level rise (SLR) as well as changes in wave conditions, storm surges, ocean circulation, ocean acidification, water temperature, and changes in precipitation¹⁶. The interactive effects of multiple stressors, such as extreme events and SLR, may drive some coastal ecosystems to sudden and irreversible shifts. These shifts could result in abrupt or nonlinear changes in ecosystem quality and/or the surpassing of thresholds¹⁷ leading to a reduction in valued resources and ecosystem services¹⁸. Projections of globally averaged SLR range from 0.3 m to 0.98 m (by 2081–2100 relative to 1986–2005)¹⁹. Future storms are expected to become more extreme and mean wave conditions are also expected to be altered by climate change²⁰. Storm surge intensity and frequency are both expected to increase in the future²¹. These climate-driven changes are likely to result in significant morphological change, especially along the sandy coastlines of the world²². The decline in the ability of coastal ecosystems to provide coastal protection has profound implications for the communities that are dependent on them²³.

India ranks 18th in the world in terms of coastline length (**Figure 1**) with 7,517 km of coast including island territories²⁴. In 2000, 64 million (6.1 %) of the total population lived in the coastal areas of India with a projected increase to 216 million (10.3 %) by 2060 under a high-growth scenario²⁵. Impacts of climate change on the coastal areas caused by storm surges, SLR, high wind, and wave velocity is felt more acutely in these areas and by the fishing community. Climate change issues are of major concern for coastal regions of India mainly because of the vulnerability of the poor to climate change; and because of large spatial and temporal variations in the climate²⁶. India has been identified as one of the 27 most vulnerable countries to accelerated SLR (UNEP, 1989). The low-lying areas of Lakshadweep Island and the east coast are particularly vulnerable to SLR²⁷. The east coast of India is also more vulnerable to

storms²⁸. Climate change could lead to large areas of land being susceptible to intensified flooding, and salinization, which might lead to its abandonment in West Bengal (India) and Bangladesh²⁹. Coastal flooding due to storm surge and high tides is a serious risk for inhabitants of the Ganges–Brahmaputra–Meghna delta. In the coastal cities of India, high population densities mean many are vulnerable to storm surges and tropical cyclones, both of which may be more extreme under climate-change scenarios³⁰.

One of the ways to reduce risks and vulnerabilities in the coastal areas is to have effective government policy informed by an assessment of risks, which focuses on risk reduction through conservation of coastal ecosystems and tries to mitigate the deleterious effect that climate change is already having on coastal risk. The Ministry of Environment, Forests and Climate Change is the main ministry at the federal level responsible for framing rules, policies, and regulations for the protection and conservation of the environment in India. The National Action Plan on Climate Change (NAPCC) 2008¹ is the main plan in India for adaptation and mitigation of climate change effects across 8 different sectors. The main regulation for the coastal areas is the Coastal Regulation Zone (CRZ) Notification, 2019³¹. This Notification has detailed guidelines and was enacted to conserve and protect the unique environment of coastal stretches and marine areas, provide livelihood security to the fisher/local communities in the coastal areas, and to promote sustainable development. The Notification demarcates the coasts of the country and the offshore area up to the territorial water limit, into different zones. In each zone, only permitted activities can be carried out. Enforcement powers for these regulations lie with the federal/provincial government.

The overall goal of my thesis was to evaluate the degree to which the National Action Plan on Climate Change of 2008 and the Coastal Regulation Zone of 2019 address the ability of coastal ecosystems to reduce risks in the face of climate change. Based on my analysis of risks and policy, I suggest modifications in the plan and the regulation to better safeguard this key ecosystem service. The specific objectives of my study are to:

- i. Summarize risks faced by coastal areas in India which would impact coastal risk to demonstrate the need for a robust policy which addresses the threat of deterioration of the ability of coastal areas to reduce risks in the face of climate change;
- ii. Analyze two policies to determine the extent to which they address the role of coastal ecosystems in mitigating risks which arise from the impacts of climate change on coastal areas;
- iii. Describe key modifications to the two policies to better position them to reduce the impacts of climate change through the protection of coastal ecosystems.



Figure 1: The coastline and coastal states of India of

¹ <http://moef.gov.in/division/environment-divisions/climate-changecc-2/national-action-plan-on-climate-change/>

The logic model, used in my thesis is shown in **Figure 2** below.

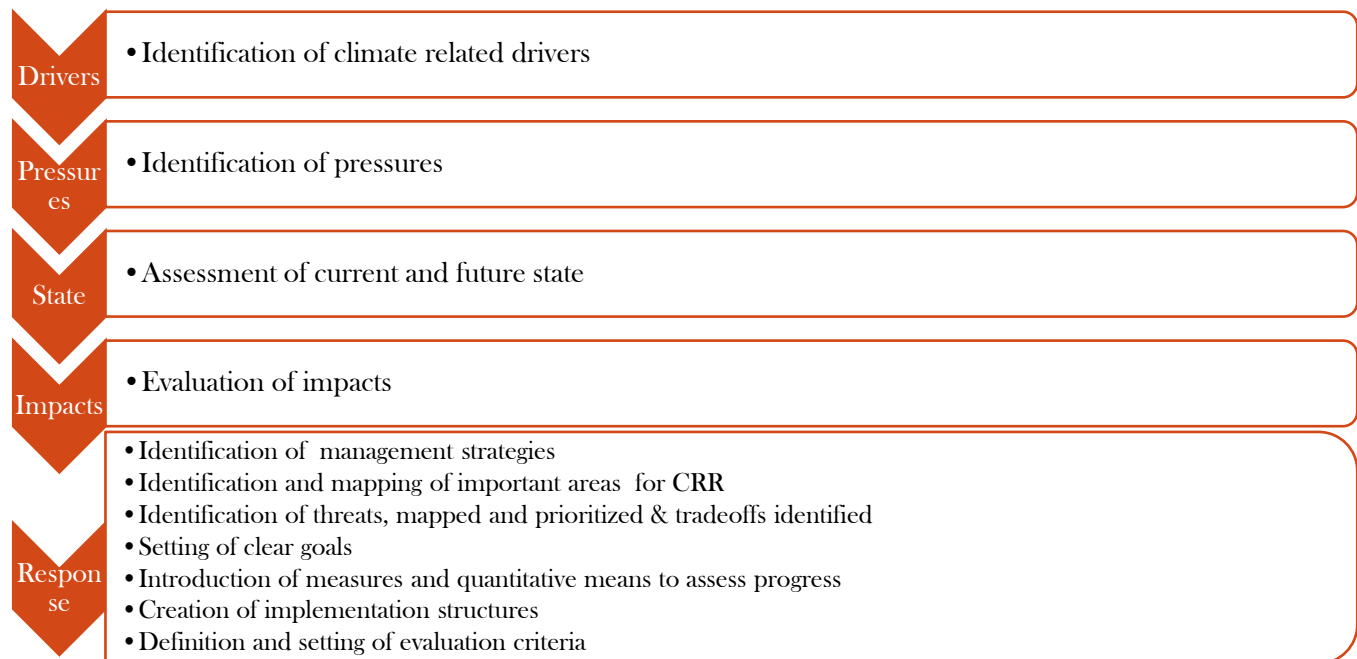


Figure 2: Logic model adopted for the analysis of plans/regulation in my thesis

Methods

Summarizing threats to coastal ecosystems in India that would impact the delivery of coastal risk reduction

I used the Coasts at Risk (C@R)³² Index to calculate coastal risk for the nine coastal states of India to assess the level of risk faced by each and whether these risks are significant. The C@R Index is based on the concept that the intensity of a natural event leads to an escalation in coastal hazards, the experience of which is affected not only by natural exposure to risk but also by the social, economic and ecological conditions of a society. The C@R Index is composed of 33 indicators, under two broad categories—Exposure and Vulnerability. Exposure refers to the number of people who may be affected by coastal hazards like storms, storm surges, floods, tsunamis, and SLR. Vulnerability consists of parameters of susceptibility, coping, and adaptive capacity. The C@R Index is calculated by summing the indices of susceptibility, lack of coping capacity, and lack of adaptive capacity to calculate a Vulnerability Index that describes the social factors of risk that can turn a natural event into a disaster. The various indicators of Exposure lead to the calculation of an Exposure Index, which signifies the share of a population exposed to a hazard event. To calculate the overall C@R Index, the Vulnerability Index is multiplied by the Exposure Index. One hundred thirty-nine countries³³ have been categorized (on the basis of calculations for the different indicators) into very low, low, medium, high, and very high on the Exposure, Vulnerability, and C@R Indices. While India falls into the medium category for all the parameters, I used the benchmarks for the different categories to compare the results I calculated for the 9 coastal states.

I developed a land-cover change map (from the shoreline to 10 km inland) to explore changes in coastal ecosystems that provide coastal risk reduction. I used mapped land cover from two time periods (1992 and 2018) from the Copernicus Satellite Data hosted by the European Space Agency³⁴. I also developed a map of coastal population for the time period 1990 and 2015 using data from the Copernicus Satellite hosted by the European Space Agency. These two change maps provide visual indication of the degree to which risks in coastal areas have changed over the years. The existence of coastal ecosystems plays a vital role in coastal risk reduction and a decrease in their area likely indicates that coastal risk reduction would be impacted, leaving the coastal communities more vulnerable to more frequent and intense extreme weather events. The change in the number of people living in the coastal areas has two implications. First, if the population of coastal communities continues to increase, more people will be vulnerable to the risks brought on by climate change. Second, an increase in the coastal population would likely negatively impact natural coastal ecosystems. A loss in coastal ecosystems would further contribute to increased risks from the more intense and frequent extreme natural events brought on by climate change.

Policy Analysis

I selected NAPCC 2008 and CRZ 2019 from the universe of policies legislated by the Government of India for analysis as these policies have the most potential to be leveraged to reduce climate impacts on coastal risk. The Government of India introduced a policy for disaster management in 2009 called the National Policy on Disaster Management. The policy proposes a proactive prevention, mitigation and preparedness-driven approach for conserving developmental gains and to minimize loss of life, livelihood and property. Its focus is on relief and rescue operations after disasters. Though the policy recognizes that climate change will lead to an increase in disasters, it does not lay out a strategy to take proactive steps to address climate change and its impacts. Further, it does not mention coastal risks. Hence, I did not choose this policy for analysis. NAPCC 2008 is a plan for addressing climate change issues and CRZ 2019 is a regulation that lays down rules for protection of the coastal areas and

management of activity in these areas. Because these two legislations directly address risks of climate change and specifically, coastal impacts, I choose them for analysis.

NAPCC 2008: The National Action Plan on Climate Change (NAPCC) was launched in 2008 and created 8 national missions. NAPCC 2008 contains multi-pronged, long-term, and integrated strategies for achieving key goals for addressing climate change. National missions were created for solar energy, energy efficiency, sustainable habitat, water issues, safeguarding the Himalayan ecosystem, greening India, agriculture issues, and development of knowledge about climate change.

I analyzed NAPCC 2008 using a keyword analysis to assess the extent to which it articulated issues like ecosystem services, coastal risk reduction, and ecosystem services in coastal areas, climate change, and climate change in the coastal areas. A list of keywords on the basis of which this policy was analyzed is shown in **Table 1**. The list of keywords chosen reflect the drivers³⁵ (climate change and coastal risk related climate drivers—extreme weather events, sea level rise, storm surge, cyclones, wave velocity, tsunami, wind speed), the coastal systems³⁶ at risk (mangroves, wetlands, beaches/dunes, corals, sea grass, marshes) as well as subject matter related words. Analysis of the mention and relevance of the mention of the different parameters related to these issues would provide an indication of whether coastal risk reduction and climate change have been acknowledged and measures to address these have found a place in NAPCC 2008. The inclusion of these topics in the policies would also indicate that the government takes these risks seriously and has an approach or plan to address them. I gave each occurrence of a key word a score (0 to 3) representing the relevance of the occurrence to the ability of ecosystems to protect against coastal hazards in the face of climate change: (0— no mention of the keyword; 1— low relevance—when the keyword is mentioned but not in context of climate change/ecosystem services/coastal risk reduction/coastal ecosystems; 2— medium relevance when the keyword is mentioned but does not include any link to climate change, ecosystem services/coastal risk reduction/coastal ecosystems and 3— high relevance—when the keyword provides a connection between the coastal ecosystem and the services they deliver and the impact of climate change on costal ecosystems and services).

Subject matter related words
Coastal risk reduction
Climate change
Coastal ecosystems
Ecosystem services
Climate related drivers
Sea level rise
Extreme weather events
Storm surge
Cyclones
Wave velocity
Tsunami
Wind speed
coastal ecosystems at risk
Mangroves
Wetlands
Beaches/dunes
Corals
Sea grass
marshes

Table 1: List of Keywords used for analysis of NEP 2006 & NAPCC 2008

CRZ 2019: The Coastal Regulation Zone (CRZ) Notifications were introduced in India to govern human and industrial activity close to the coastline and for the protection of the fragile coastal ecosystem. They were first introduced in 1991, updated in 2011 and again in 2019. The stated objective of CRZ 2019 is to categorize the coastal areas as coastal regulation zones “with a view to conserve and protect the unique environment of coastal stretches and marine areas, besides livelihood security to the fisher communities and other local communities in the coastal areas, and to promote sustainable development based on scientific principles taking into account the dangers of natural hazards, sea level rise due to global warming”. I used the Drivers-Pressures-State-Impacts-Response (DPSIR) framework to analyze CRZ 2019. DPSIR is a foundational environment framework that was developed from the PSR (Pressure-State-Response) framework³⁷ and adapted and largely promoted by the OECD (Organization for Economic Cooperation and Development) for its environmental reporting. Several international organizations, such as the United Nations Environment Program (UNEP) have also adopted the framework. The DPSIR

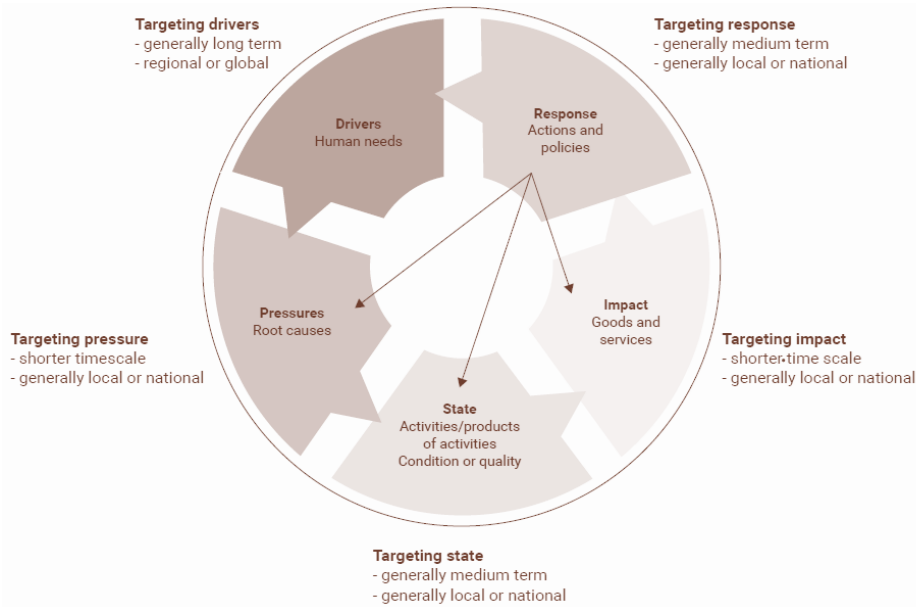


Figure 3: DPSIR Framework (GEO 6, UNEP)

framework, as shown in **Figure 3**, represents a systems-analysis view in which the driving forces of social and economic development exert pressures on the environment, which change the state of the environment. The changing state of the environment leads to impacts on people and ecosystem health, which then initiates human responses to mitigate these impacts, such as policies, political interventions, controls, changing

investment decisions etc., to influence human activity. Finally, these responses feedback to affect the state of the environment, either directly or indirectly, through the driving forces or the pressures. Existing policies increasingly need to be assessed in terms of how they address the drivers and impacts of environmental challenges (UN Environment, 2007).

To evaluate the CRZ 2019 according to the DPSIR framework, I developed criteria and detailed parameters for analysis (**Appendix 1**). The main criteria developed is depicted in the **Figure 4** below:

Driver	Pressures	State	Impacts	Response
<p>climate change</p> <ul style="list-style-type: none"> • severe storms • extreme sea level • high wind & wave speeds • surge potential • disruption in natural ecosystems • relief 	<p>changes in land use</p> <p>overpopulation</p> <p>deforestation</p> <p>mining on seabed/beaches</p> <p>infrastructure projects</p>	<p>assessment of flood control services</p> <p>assessment of inundation potential</p> <p>shoreline change</p> <p>state of ecosystem</p> <p>extent of dissipation of wind/wave energy</p> <p>regulation of SLR</p> <p>extent of relief preserved</p>	<p>biophysical impacts</p> <p>impacts on natural processes and systems</p>	<p>strategy for reduction of threats</p> <p>identification and mapping of vulnerable areas</p> <p>threats mapped/tradeoffs analysed</p> <p>clear goals set</p> <p>measures and measurable objectives set</p> <p>implementation structures created</p> <p>evaluation criteria set</p>

Figure 4: Main criteria for analysis of CRZ 2019 based on DPSIR framework

The criteria set according to DPSIR framework is discussed below along with the sources of the criteria.

DRIVERS: Identification of climate related drivers

United Nations Environment Programs defines drivers as fundamental processes in society, which drive activities having a direct impact on the environment. As mentioned in IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—Coastal Systems and Low-lying Areas), the drivers that affect coastal systems are human related (socioeconomic development, nutrients, hypoxia, sediment delivery) and climate related (relative sea level rise, storms, extreme sea level, temperature, CO₂ concentration, freshwater input, ocean acidification). Because my thesis examines the impact of climate change on coastal risk reduction and sufficiency of government policy in this regard, I took only the climate change criteria on board for assessment. Further, not all of the climate change drivers mentioned above are relevant to coastal risk reduction, so I used the drivers relevant to coastal risk reduction (table 5.1: relative sea level rise, winds, waves, storms, and extreme sea levels) for assessment³⁸. I evaluated the degree to which these climate drivers were identified and addressed in the policy/regulations.

PRESSURES: Identification of pressures

Pressure is human activity or driving force³⁹ induced by human activities on the environment⁴⁰. The pressures which impact coasts and relevant to the delivery of coastal risk reduction include in land use, sand mining, dredging, industries, infrastructure, deforestation, coastal defense works (GEO 6). These pressures exacerbate the impact of climate change on coastal ecosystems and on risk reduction. I used each of these pressures in my analysis because they are the ones identified by IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—Coastal Systems and Low-lying Areas), Global Environment Outlook (GEO) 6, and A Handbook for measuring the process and outcomes of Integrated Coastal and Ocean Management by the United Nations Educational Scientific and Cultural Organization (2006).

STATE: Assessment of current and future state

State has been defined as the condition of the environment resulting from the pressures (Millennium Ecosystem Assessment, 2005). With regard to the objectives of the thesis, the state is indicative of the present status of the coastal ecosystems and their ability to provide the risk reduction service. Its importance lies in the fact that decrease in this ecosystem service will result in increased vulnerability and hazards faced by coastal communities. Further, knowledge about the “state” and “pressures” is the starting point for planning how the environment can be influenced to improve human well-being (MEA, 2005). With regard to coasts and coastal risk reduction, my assessment of state included information regarding the extent of maintenance of ecosystems, as well as the potential extent of flooding, inundation, as well current and projected storm surge, wind/wave energy, SLR and relief, as mentioned in IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—Coastal Systems and Low-lying Areas). Knowing whether these have increased or decreased would help us to come to a conclusion about the state of coastal risk reduction.

IMPACTS: Evaluation of impacts

These are functional changes resulting from changes in the characteristics of the environment. These could be environmental, social or economic, contributing to the vulnerability of both people and the environment (MEA 2005). For the assessment of impacts I used those identified in the IPCC Report– Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Specifically, I evaluated the policy for mention of impacts to on natural ecosystems (rocky coasts, beaches, sand dunes mangroves, wetlands, seagrass beds & coral reefs) and biophysical impacts (flood damage, submergence of drylands (reefs, barrier islands, and shorelines), dryland loss due to erosion and wetland loss and change)⁴¹. There are also impacts on human systems, however I did not include these in my analysis as my focus was on the protection of coastal ecosystems and the delivery of coastal risk reduction.

RESPONSE

These are societal or individual actions taken to overcome, reduce, correct or prevent negative environmental impacts; correct environmental damage; or conserve natural resources. These may include regulatory action, environmental or research expenditures, changes in management strategies, and the provision of environmental information (MEA 2005). India has a response in the form of CRZ 2019. For this criteria under the DPSIR framework, I developed detailed parameters to assess the effectiveness of the policy response. These detailed parameters for the analysis of policy were based on a systems approach⁴² which is about viewing events as a system and/or part of larger systems⁴³. Systems thinking advocates the treatment of systems as wholes, composed of related elements. According to Hwang⁴⁴, systems thinking enables one “to see the overlapping and ever-expanding relationships among systems in multiple dimensions.” The systems approach has also been used to devise management strategies for coastal areas⁴⁵. Broadly, I assessed CRZ 2019 on these detailed parameters which are not exhaustive but are the most commonly used criteria for assessment of policy in the current literature⁴⁶.

(i) Were management strategies for coastal systems identified? UNEP identified the management strategies for coastal management as: Integrated Coastal Management, Integrated Coastal Zone Management, Marine Protected Areas, Ecosystem Based Management, and Coastal Watershed Management. Integrated Coastal Area Management was identified by the Food and Agriculture Organization as a newly emerging approach. International Union for the Conservation of Nature (IUCN) proposed Adaptive Management as a strategy for managing the coastal areas. I analyzed which of these responses had been adopted in CRZ 2019.

(ii) Were areas important for providing coastal risks reduction services identified and mapped? Identification and mapping of areas of interest provides a useful mechanism to link scientific and other information with the policy-making environment, and can visually present sometimes complex information in a more accessible way. According to Global Environment Outlook (GEO) 6 and UNEP, some of the areas important for identification and mapping for coastal risk reduction service include: mapping of the landward extent of the coastal environment, important areas for preserving and protecting natural character, natural features and natural landscapes of the coastal environment, coastal resources or processes which require protection from adverse cumulative effects, areas which are potentially affected by coastal hazards over at least the next 100 years, areas of the coastal environment where particular activities and forms of subdivision, use and development are inappropriate and priority areas for restoration and rehabilitation. I assessed whether the identification and mapping of coastal areas in CRZ 2019 was done on similar lines.

(iii) Were threats mapped and prioritized and tradeoffs identified in the policy? According to IPCC Report– Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral

Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—Coastal Systems and Low-lying Areas), threats to delivery of ecosystem services, including that of risk reduction could be biophysical in nature, threats to natural systems and threats to human systems. I analyzed threats to biophysical and natural systems as they were the most relevant to coasts and to risk reduction. I also analyzed whether tradeoffs were included in the policy (IPCC).

(iv) Were clear goals regarding risk reduction set in the policy? Setting of clear goals⁴⁷ is an important element of public policy. According to Global Environment Outlook (GEO) 6, clear goals, which are relevant to the reduction of coastal risk include goals relating to creation of a consensus-based process to formulate a shared set of goals, setting of environmental goals for sustainability of coastal ecosystems in light of climate change and measures for sustainable development of coastal areas in light of climate change.

(v) Were measures introduced for preserving ecosystems to reduce the threats of climate change/other threats and quantitative objectives set to measure progress? A policy should consist of specific measures to fulfil the aims, objectives and purpose of the policy and should conform to the goals set out⁴⁸. In line with the goals, I assessed whether CRZ 2019 had introduced measures for creation of a consensus-based process to formulate a shared set of goals relating to coastal risk reduction, setting of environmental goals for sustainability of coastal ecosystems in light of climate change and for the sustainable development of coastal areas in light of climate change impacted coastal risk reduction⁴⁹.

(vi) Were implementation structures for mitigating the impact of climate change on coastal areas and the services they provide created? Structures need to be created to implement the measures in the policy⁵⁰. Some of the structures to be created for implementation include sustainability of initiative, separate funding mechanisms with controls, involvement of stakeholders, local management initiatives along with traditional rights, g, stakeholder consultation, independent standard setting body, independence of monitoring arrangements, improved surveillance methods and development of norms and standards⁵¹.

(vii) Were evaluation criteria for assessing impact of management strategies defined and set? To assess the effectiveness of measures included in the policy, it is required to eluate the performance of these measures⁵. Some of the evaluation methods relevant to coastal risks (A Handbook for Measuring the progress and outcomes of Integrated Coastal Management (UNESCO, Intergovernmental Oceanographic Commission)) and GEO 6—UN Environment 2019) consist of outcome indicators which assess the extent of coastline stabilization and protection from hazards and coastal sustainable development⁵².

To evaluate each parameter in each of the five categories (drivers, pressures, states, impacts, and responses), I gave it a score of 0 to 2 with 0 being no mention of the parameter in the policy, 1—brief mention, and 2—detailed description in the policy. In this context, “brief mention” implies that the parameter features in the policy but is not related to the goal of reducing coastal risks arising from climate change. “Detailed description” implies that the policy contains a detailed description of how the parameter will serve to reduce coastal risks. All the criteria/detailed parameters used in this thesis (as discussed in this section) and the scores for each of these are depicted in columns 1 & 2 of **Appendix 1**.

It is important to note that in this thesis, I have not studied the implementation or the effectiveness of the selected policies. This is mainly due to the fact that it is difficult to get data about the state of implementation, without which, the evaluation of effectiveness is difficult to determine. Also, it is difficult to attribute causality from data about implementation. As such, the present study only focuses on how well the policy was designed to take into account all relevant data, instruments, and viewpoints to reduce the

impact of climate change and other threats that coastal ecosystems face and the services they provide. Many theorists⁵³ state that the appropriate crafting of policies can overcome implementation difficulties attributable to vague goals and complex implementation structures. Further, many sectoral programs might include activities to reduce climate change impacts but these were not analyzed because they were not backed by a policy that incorporated climate change impacts and other threats on coastal ecosystems and the services they provide. Such programs are only short term and do not reflect a sustained commitment, unless backed by policy. Hence, this paper proceeds on the assumption that a well-crafted policy which takes all relevant viewpoints, instruments, techniques, data etc., into account will go a long way in delivering an attainable model for fulfilling the core vision of environment stewardship of the coastal areas in the face of climate change and other pressures in a manner that is beneficial to all stakeholders.

Results

Analysis of risks to coastal ecosystems

Coasts at risk (C@R)

Exposure: The scores indicate that the share of population facing hazards like SLR, tsunamis, and storm surges is highest in the coastal regions of West Bengal (0.30), Odisha (0.25) and Andhra Pradesh (0.14) as compared to the other 6 states (Figure 5).

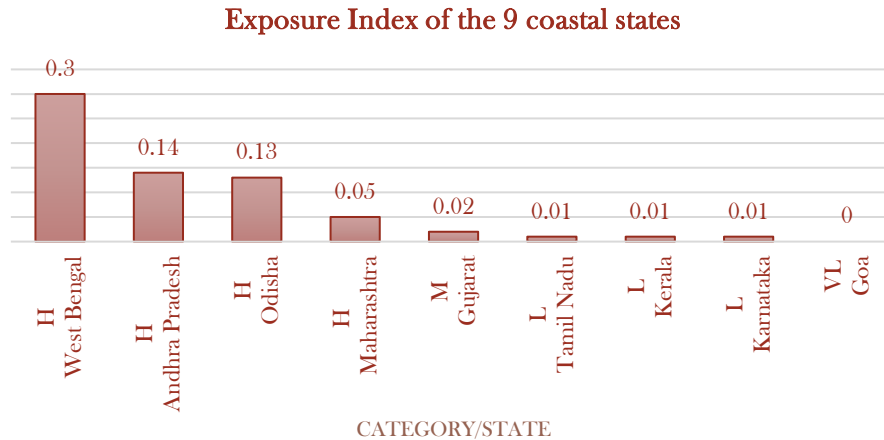


Figure 5: Exposure Index of the 9 coastal states calculated by means of the method in Welle et al., and arranged in descending order of risk (H—high, M—medium, L—low & VL—very Low)

Comparison with international benchmarks (as specified in the paper by Welle et al.) show that West Bengal, Andhra Pradesh and Odisha fall into very high exposure risk category (0.0705 - 0.5955), Maharashtra falls into the high risk category (0.0229 - 0.0704), Gujarat falls into the medium risk (0.0104 - 0.0228), Karnataka, Kerala and Tamil Nadu fall into low risk category (0.0041 - 0.0103) and Goa falls into very low exposure risk (0.0003 - 0.0040) category.

Vulnerability: Vulnerability was generally similar across the 9 states although Odisha was ranked the most vulnerable (0.41) followed by West Bengal (0.37), Gujarat (0.35) and Tamil Nadu (0.34) (Figure 6). This would mean that the coastal community in the coastal areas of these states do not have sufficient

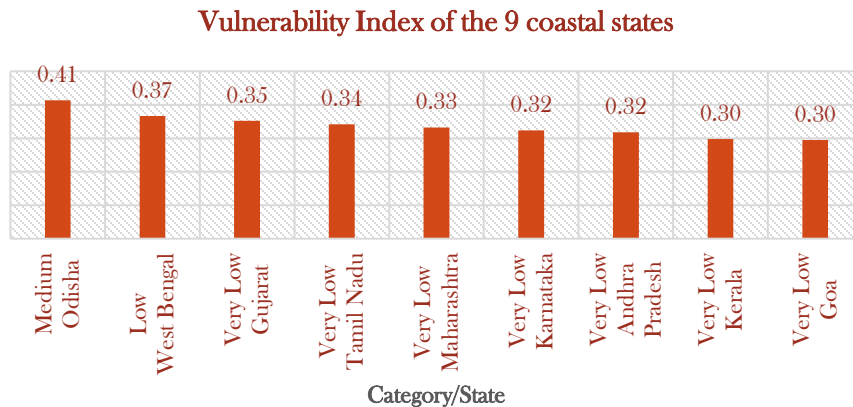


Figure 6: Vulnerability Index of the 9 coastal states calculated by means of the method in Welle et al., and arranged in descending order

social and economic resources to face the distress which coastal hazards would bring. According to the international benchmarks, Odisha falls in the medium category (0.4157 - 0.4719), West Bengal falls in the low category (0.3656 - 0.4156) and the other states fall in the very low category (0.2791 - 0.3655). Thus, Odisha and West Bengal have

relatively lower adaptive and coping capacity and are more susceptible to the effects of coastal hazards.

Coasts@ Risk: The C@R index was computed for the 9 states (Figure 7). While West Bengal (0.11) and Odisha (0.05) have the highest C@R among the coastal states, Goa (0) has the least. High C@R signifies that exposure to risks like storm surges, sea level rise, strong wind and wave velocity events,

C@R of the 9 coastal states

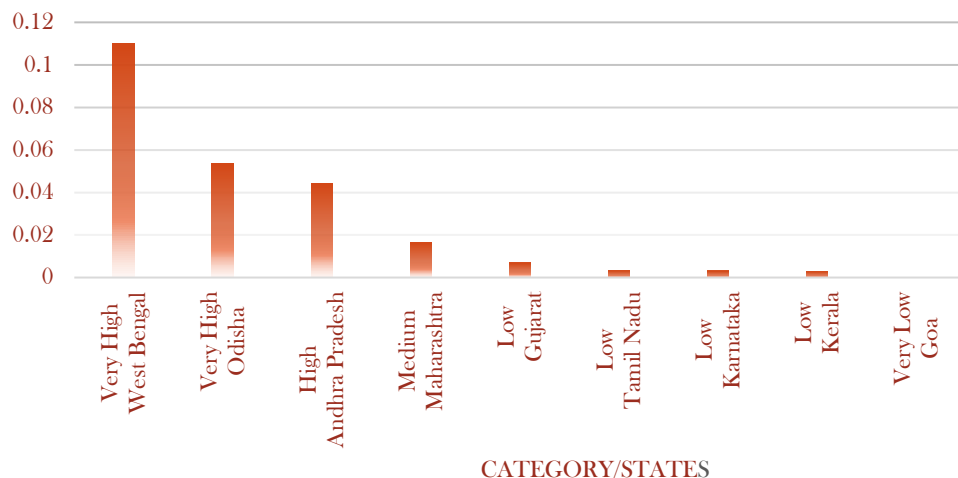


Figure 7: C@R of the 9 coastal states calculated by means of the method in Welle et al., and arranged in descending order

tsunamis, and other similar extreme weather events in these states was high, as compared to other coastal states. Since vulnerabilities in these states were also greater in comparison to the other coastal states, there was increased probability of a hazard event in these states turning into a disaster. When compared to international benchmarks, West Bengal and Odisha

fall in the very high risk category (0.0317 - 0.2702), Andhra Pradesh falls into the high risk category (0.0101 - 0.0316), Maharashtra falls into the medium risk category (0.0048 - 0.0100), Tamil Nadu, Karnataka and Kerala fall into the low risk category (0.0019 - 0.0047). Goa and Gujarat fall into the very low risk category (0.0001 - 0.0018).

Land cover and population change over time

Land cover

Fifteen percent of land in the coastal area has seen change in use in the last 26 years (Appendix 2). Specifically, the analysis shows that 3.6 % of natural cover has changed to human interventions affected areas, mainly agriculture. Forest cover has decreased by 3 % and the area covered by water bodies has decreased by 3.5 % of total land area between 1992 and 2018. While 1% of the natural cover and almost 2 % of cropland has been converted to urbanization, more than 1% and 0.3 % of water bodies have been converted to agriculture and urbanization respectively. Overall, the area under urban settlements has increased by 110 % of total land between 1992 and 2018. Further, areas which have forest area more than 50 % and cropland of less than 50 % have seen a decrease of 15 % between 1992 and 2018, indicating slow degradation of forested areas and its use in agriculture.

Changes in land cover are shown in Table 2 below:

Category	1992	2018
Total coastal area: 69,275 sq km		
Forests	23295 sq km (34 % of total coastal land area)	22731 sq km (33 % of total land area),
Human interventions, mainly agriculture	36661 sq km (53 %)	35610 sq km (51 % of total area)
Urban settlements	1713 sq km (2.5 %)	3592 sq km (5 %) of total area
Water bodies	7608 sq km (11%)	7342km (10.5 %)

Table 2: Changes in Land Cover, derived from GIS maps of land cover (1992 & 2018) from the European Space Agency

While the changes in land cover over time are not dramatic, it is important to remember that maps do not fully reflect the features on the ground and could under-estimate the extent of change. They also do not show the quality of vegetation or small gaps in vegetation. Further, not all land cover changes are captured in the maps. Especially difficult to capture is the conversion of a true forest to a mixed forest which could signify forest degradation as it involves the evolution of a true forest to a mix of natural vegetation consisting of shrubs, herbaceous cover and grassland. In the coastal areas of India, mixed landscapes have changed by almost 15% between 1992 and 2018 and could indicate gradual replacement of a forest with shrubs, grasslands and other similar vegetation, including crops. The LC maps also do not capture features like beaches, sand dunes, sea grass, and salt marshes. Hence change in their nature and area cannot be estimated through the use of GIS maps. Keeping these limitations in mind, it could be that GIS mapping has underestimated the decrease in natural features between 1992 and 2018. The fact that the decreases could be larger is matter of great concern for conservation and preservation of ecosystems and the services they provide.

Population changes over time

The entire coastal area (from shoreline to 10 km inland) was analyzed to identify whether the number of people living in these areas had increased or decreased over time. These have been mapped and attached as **Appendix 3**. An increase in population would indicate that there was a migration to the coastal areas and decrease would indicate that population was moving away from coastal areas. Out of the total coastal area of 68, 836 sq km, between 1990 and 2015, analysis indicated that population in the coastal areas had increased in 26,780 sq km (39 % of the coastal land area mapped). A major increase took place in 19 % of the coastal areas, where population increased more than 100 % between 1992 and 2018. In 3.5 % of the coastal area, an increase in population between 0-10 % took place, in 4.5 % of coastal area, an increase in population between 10-25 % took place. An increase of 25-50 % took place in 6% of coastal areas while an increase between 50-100% took place in 5.7% of the coastal area. Population had remained the same in 36,369 sq km (53 % of total area mapped) while it decreased in 5707 sq km (8 %) of the total coastal area mapped.

The increase in population in 39 % of the coastal areas and population increase of more than 100 % in 19 % of the coastal area signifies that more people will face destructive impacts of extreme coastal natural events. Further, more people living in coastal areas will likely result in more land conversion—which is likely reflected in the land-use changes I observed.

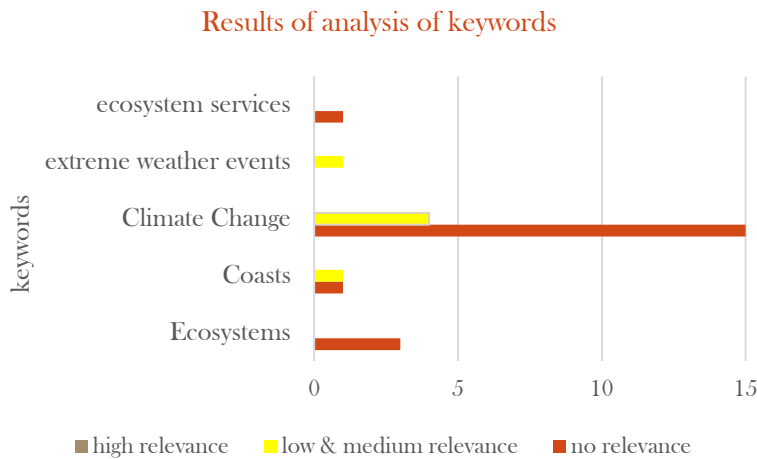
Overall, the analysis of risks to coastal ecosystems and coastal risk reduction by means of computation and analysis of C@R for the 9 coastal states of India showed that West Bengal and Odisha and to some extent Andhra Pradesh face high levels of exposure from coastal hazards. Consequently, they will face unmanageable disasters from coastal hazards like sea level rise, tsunamis, and storm surges. Climate change will further exacerbate and magnify these risks, making these hazard events more frequent and more intense. These states also have less institutional and societal resources to cope with and adapt to these risks as their vulnerability is on the higher side. Thus, increased coastal risks have the potential to cause a lot of suffering and distress to the coastal community in these states. Change analysis of land cover by means of GIS mapping showed that urbanization in the coastal areas has increased drastically and the increase is at the expense of coastal ecosystems like water bodies, wetlands, and forests. Population change analysis shows that coastal areas are facing huge increases in population, indicating that more people are moving to the coastal areas. As such, the coastal areas are facing increasing risks from extreme natural events which are mounting due to climate change – first due to decrease in natural cover which provides

coastal risk reduction and second, from the increasing number of people moving to the coastal areas which would increase the pressure on the coastal natural cover. Further, greater number of people would suffer the consequences of more frequent and more intense extreme events due to decrease in the ability of the coasts to provide coastal risk reduction.

Policy Analysis

NAPCC 2008

Analysis of NAPCC 2008 showed that **coastal/ coast/coasts** have been mentioned in the policy (Figure 8). However, the mention of coastal/coast/coasts has been done only with reference to the need for research on the impact of climate change on coastal communities. There is no mention of coasts with



Keywords not mentioned: Ecosystem, ecosystem services, coastal risk reduction, Extreme natural events, coastal ecosystems, mangroves, wetlands, Sea level/Sea Level rise, Beaches/dunes, Coral/ corals/ coral reefs, Sea grass, Marshes, Tsunami, Storm/ storm surge, Cyclones, Wave velocity & Wind speed

Figure 8: Results of scoring for mentions of keywords and their relevance

reference to the ecosystem services they deliver, specifically the role of coasts in reducing risk and impacts due to climate change. The NAPCC 2008 only recognizes the impact of climate change on coastal livelihoods but not on coastal ecosystems and the services they provide. Not surprisingly, there are no plans or measures in the policy for adaptation to or mitigation of the threats of climate change to the coastal ecosystems. The NAPCC 2008 does mention **ecosystems** but it recognizes only the Himalayan region of India as an ecosystem where measures need to be taken for mitigation and adaptation. It does not mention **coastal ecosystems** at all, so the NAPCC 2008 does not connect climate change and its effects on coastal ecosystems. Further, the policy fails to mention any of the various constituents of coastal ecosystems like **beaches, coral reefs, sea grass, marshes, wetlands, and mangroves**. Hence impact of climate change on these constituents of the coastal ecosystems and their role in mitigating the increasing coastal risks due to climate change is not addressed at all in the policy

The NAPCC 2008 also does not recognize **ecosystem services** provided by coastal areas. NAPCC 2008 also does not mention **coastal risk reduction** which is a key ecosystem service provided by the coastal ecosystem. The policy is silent about measures to mitigate coastal risks which will increase due to climate change. It only talks about rejuvenation of forests to create carbon sinks and provide other ecological services but does not talk about rejuvenation of coastal forests and mangroves which also provide very important ecosystem services and are impacted by climate change. Since NAPCC 2008 is a policy on approaches and means to adapt and mitigate the effects of climate change, **climate change** is mentioned frequently. However, the relevance of these mentions to the themes of this thesis is very low. NAPCC 2008 does not talk about the impact of climate change on coastal ecosystems. It does not recognize the fact that ecosystem services like coastal risk reduction will decline due to the impacts of climate change. The policy creates 8 missions to combat climate change but there is no mission to mitigate the impact of

climate change on coastal ecosystems, even though there is a mission to tackle the effects of climate change on the Himalayan ecosystem. Thus, climate change mitigation and adaptation for the coastal areas is completely missing in NAPCC 2008.

Further, I also examined whether specific impacts of climate change on coastal ecosystems and the services they provide were mentioned. I found that extreme weather events are mentioned in NAPCC 2008 in the context of setting up a disaster warning system to reduce vulnerability of the coastal community. NAPCC 2008 does not mention SLR or its potential impacts on coastal communities.

CRZ 2019

1. Drivers

Climate related drivers were not identified and addressed in the CRZ 2019. Climate-related drivers like severe storms, extreme sea levels, wind exposure, wave exposure, relief, and surge potential result in stress on coastal ecosystem services, including coastal risk reduction. Articulation of the magnitude of the impact of these drivers is important as this will lead to a recognition of the extent of the problem. Analysis of CRZ 2019 shows that these climate related drivers affecting the coastal ecosystems and the delivery of coastal risk reduction were not identified in the policy. The policy also did not refer to any such study done by any other agency of the Government of India that acknowledged these climate drivers and their impacts on the Indian coastline.

Tools like demarcation of hazard linesⁱⁱ and use of setback linesⁱⁱⁱ are significant markers for climate and associated risks faced by coastal communities and are used to map the climate change drivers and their effects on the coastal areas. In this regard, the hazard line for the Indian coast has been delineated by a scientific agency of the Government of India and in CRZ 2011 (the older regulation), it was to be used to establish the vulnerable areas. Accordingly, the area between the High Tide Line (HTL) and the hazard line was classified as vulnerable where no development activities could take place. In the area between the hazard line and 500 m inland, no development activities could take place, except in exceptional cases. The hazard line is not mentioned in the main body in CRZ 2019 and is no longer to be used as a tool for demarcation of vulnerable areas. As a result, the hazard line is not used to identify the vulnerable areas (Paragraph 2) and restrict development activities in any part of the coastal area (Paragraph 3).

2. Pressures

CRZ 2019 partially identifies the pressures the coastal areas face: Human activities can alter coastal areas and their resources in many ways, particularly through land-based activities. Identification of these pressures, their extent and impacts will enable policy planners can incorporate specific measures in the policy to mitigate these pressures, when the impact of these measures is significant. Analysis of CRZ 2019 showed that only some pressures like pollution, impacts due to setting up industries, mining, and infrastructure activities have been identified. Other pressures on the coastal ecosystems like construction of engineered coastal defense projects, changes in bathymetry due to dredging, changes in coastal land use, and deforestation have not been identified in CRZ 2019. Lack of recognition of the full complement of

ⁱⁱ Used to delineate the areas expected to be impacted by coastal processes including those areas to be impacted by climate change in the coastal areas.

ⁱⁱⁱ a prescribed distance to a coastal feature such as the line of permanent vegetation, within which all or certain types of development are prohibited. The 'setback' area provides a buffer between a hazard area and coastal development

pressures impinging on the coastal ecosystems will decrease the effectiveness of CRZ 2019 in taking measures to address these pressures.

3. State

CRZ 2019 did not fully contain an assessment of the current and future status: Assessment of current and future status would give a picture of the state of the ecosystem and the services they provide, e.g., whether it is deteriorating and will do so in the future and whether interventions are required to address their deterioration. Analysis of CRZ 2019 showed that the current or the future status of these ecosystems/services was not referred to in the policy, except a small reference to the need of maintaining coastal ecosystems. This would impede the government in addressing current concerns as well as preparing for the future by means of the CRZ 2019.

4. Impacts

Impacts were partly evaluated. Climate change and other drivers and pressures will result in an increase in coastal risks, leading to distressing long term impacts on ecosystems and coastal communities. Analysis of CRZ 2019 reveals mention of some impacts on ecosystems like impacts on mangroves, coral reefs, and sand dunes were referred to. Biophysical impacts like flood damage, submergence (specifically reefs, barrier islands), shoreline erosion, dryland loss due to erosion, wetland loss and change have not been mentioned. Further, these impacts have yet to be fully analyzed and assessed for significance. Lack of complete recognition and analysis of impacts on the coastal ecosystems and the services they provide limits the ability of the government to identify the triggers or causes which lead to these impacts and put in place measures to eliminate the triggers causing biophysical and ecosystem impacts.

5. Response

(i) Management strategies for coastal areas were not completely identified. To address the threats, it is essential that management strategies be put in place for effective management and reduction of threats and for implementation of measures. A wide variety of such management approaches is possible and available. Analysis of CRZ 2019 shows CRZ 2019 contained only very limited measures of zoning and regulating activity in the coastal zones as a strategy to manage coastal areas. However, it was observed that these measures contained many exemptions and permissions, which in the long run, would weaken the efficacy of the strategy. Specifically, analysis showed that the following exemptions weakened the zoning strategy:

- Though CRZ 2019 states that no activities are to be permitted in CRZ 1 areas, analysis showed that many exemptions are provided and some activities are permitted after an approval process. For example: "Eco-tourism" constructions and activities are allowed as is mining for rare earth minerals in sand dunes, transfer of hazardous substances from ships to ports, terminals and refineries, maintenance and clearing of waterways, channels, and waste treatment in sensitive inter-tidal areas. Construction of roads on stilts is also allowed for defense, strategic purposes, and public utilities and what is strategic has not been defined. Damage to mangroves is allowed as long as compensatory plantation of mangroves takes place for which no process has been specified. Further, land reclamation, which has strong impacts on coastal ecology, has been allowed in intertidal or CRZ-IB areas, for ports and sea links. These exemptions might reduce the coastal protection services provided by the ecosystem and makes the area more vulnerable to the impacts of climate change.

- The 2019 notification also provides for "construction of memorials or monuments and allied facilities in exceptional cases" in CRZ-IVA areas which includes the "water area and the sea bed area

between the low tide line up to 12 nautical miles on the seaward side”. This will affect the fragile coastal ecosystems, particularly because it would involve land reclamation, dredging in the coastal waters etc.

(ii) Areas important for the delivery of coastal risk reduction were partially identified and mapped.

Analysis of provisions of CRZ 2019 showed that:

- In CRZ 2019, the coastal areas of India were divided into Coastal Regulation Zones I, II, III & IV. However, this zoning extended to only to a maximum of 200 m from the HTL. Zoning was done for only this very narrow strip of land. Coastal ecology and the delivery of coastal risk reduction extends beyond this minimal distance in many places and includes upland areas. These areas were not identified and mapped.
- There was no mapping of areas open or closed to development.
- The policy called for mapping of ecologically sensitive areas which had already been previously identified under the Protected Area network.
- CRZ 2019 did not have any provisions for the identification and mapping of areas important for the delivery of ecosystem services, for areas on the coast that required restoration and rehabilitation and for areas which are potentially affected by coastal hazards over at least the next 100 years

(iii) Threats to coastal areas remained to be identified, prioritized and addressed in the policy: CRZ 2019 did not identify threats to the coastal areas which would impair their ability for risk reduction. It also did not contain measures to reduce threats like inundation, submergence of drylands, dryland loss due to erosion, wetland loss and change. It also did not incorporate measures to reduce threats to human systems like settlements, infrastructure, industries, agriculture etc. Analysis of CRZ 2019 showed that many provisions in CRZ 2019 increased threats to coastal ecosystems like the provision allowing for a relaxation of floor space index for buildings in CRZ II which allows construction close to shoreline. This would increase urbanization and construction of high rises, very near the coast. In the intertidal areas, CRZ 2019 allows for construction closer to the water areas (between 50 m to 200 m from HTL) which would increase threats to infrastructure as well as human settlements. These threats were also not prioritized on the basis of severity and tradeoffs or co-benefits arising from different measures were also not incorporated in CRZ 2019.

(iv) Clear goals for coastal risk reduction were partially set in the policy: CRZ 2019 includes an introduction which stated that the coastal areas are regulated into zones “with a view to conserve and protect the unique environment of coastal stretches and marine areas, besides livelihood security to the fisher communities and other local communities in the coastal areas and to promote sustainable development based on scientific principles taking into account the dangers of natural hazards, sea level rise due to global warming”. Analysis of CRZ 2019 showed that the regulation mentioned issues like conservation of coastal areas, livelihood security, sustainable development, and the danger posed by natural hazards. However, there was no mention in the regulation about the protection of ecosystem services like coastal risk reduction, stakeholder consultation, quality of life of the coastal communities, and preservation of biodiversity of the coastal areas. Detailed analysis of the policy also indicated that the goals mentioned in the statement of intent were not fully translated into actual policy measures in CRZ 2019 as discussed below:

- Analysis showed that for CRZ II, the older notification (2011) had frozen the Floor Space Index (FSI) at 1991 levels. CRZ 2019 has relaxed this and permitted a higher FSI for construction projects. Also,

certain kinds of buildings in metro cities such as Chennai and Mumbai have been exempted from meeting the conditions required for construction in CRZ II areas in CRZ 2019. This would allow for more building activity and urbanization in the coastal areas, stressing the fragile coastal ecosystem. This would also magnify risks due to threat in delivery of coastal risk reduction as development is permitted close to shoreline.

- CRZ 2019 labels land along “tidal influenced water bodies” as No Development Zone (NDZ) in CRZ III areas. NDZ is the area where no developmental activities can take place. In CRZ 2019, the NDZ has been reduced from 100 m (in CRZ 2011) to 50 m or the width of the creek, whichever is less, in densely populated rural areas. In less populated rural areas, the NDZ has also been reduced from 200 m to 50 m. Further, prohibition on construction has been lifted in NDZ. Temporary tourist facilities, gardens/ parks, agriculture, forestry, pastures, playfields, roads, community toilets, schools, drainage/ sewerage facilities, will be allowed. Also, on landward sides of roads in NDZ, construction of resorts, hotels, and associated tourism facilities shall be permitted. Mining of rare minerals has also been allowed.

- Increased activity in the coastal areas, which has now been permitted, would allow more urbanization, encourage more tourism-related activities, and enable other development.

(v) For preserving coastal ecosystems, some measures were incorporated in the policy; however, no objective criteria to track progress were set. CRZ 2019 contained some measures to combat the effects of climate change and the pressures on coastal areas, but no indicators were specified to assess whether these measures would have the intended effects. No measures relating to ensuring sustainability of coastal livelihoods, sustainable development of coastal areas, reducing vulnerability of coastal areas, and ecosystem services in light of climate change were included.

- Analysis showed that CRZ 2019 contained interventions like conservation of mangroves, sand dunes, seagrass, coral reefs etc., however, these interventions were not complete as many activities (tourism related, port facilities, projects with strategic interest) were allowed in the areas that contained the above-mentioned ecosystems. Further, there were no measurable indicators included in the policy that could be used to arrive at a conclusion regarding whether these interventions resulted in desired results.

- For sustainable development of the coastal areas, a system of zoning was incorporated and measures to regulate activities in these zones were included in CRZ 2019. Measurable criteria, however, like land use permits/zoning for industries/ infrastructure projects received but refused due to location in coastal areas etc., were not formulated.

- No measures were incorporated in the CRZ 2019 for ensuring sustainable quality of life of the coastal community, especially in light of increase of coastal risks due to climate change.

(vi) Implementation structures were not fully created: Analysis of CRZ 2019 showed that a limited attempt was made to align the management structure with the chosen management strategy -zoning and regulation of activity in the coastal areas. While sustainability of the initiative is high as CRZ 2019 is a government regulation, no separate mechanism for funding initiatives for the coastal areas was specified and traditional rights of the fisher folk was not guaranteed approved by the central government. CRZ 2019 contained a coordinating agency called the Coastal Zone Management Authority at the level of the state (as in the earlier regulations of 1991 & 2011). Opportunities for stakeholder consultation were few. Other provisions, like consulting the traditional fishing community for construction of dwelling units or requiring a public hearing for specific projects in the CRZ area have also been omitted from CRZ 2019.

CRZ 2019 does not contain any provisions for setting up independent monitoring. No environmental surveillance methods are mentioned in the policy.

(vii) Evaluation criteria (KPIs) for assessing impact of management strategies remained to be defined and set. No outcome indicators were defined for coastline stabilization and protection from hazards, coastal development, and participation of coastal community. Hence, the government would find it difficult to assess whether CRZ 2019 was delivering the desired outcomes and whether the policy succeeded in reducing the risks the coastal areas face. The results of the analysis of detailed parameters has been exhibited in Column 2 of **Appendix 1**.

Discussion

The influential work of Daily⁵⁴ and Costanza et al.,⁵⁵ has grown the concept of ecosystem services into a vital area of environmental study, policy, and practice across the globe⁵⁶. Coastal zones are one of the most dynamic natural ecosystems of our planet and the wellbeing of coastal communities is contingent on the ecosystem services that coastal ecosystems provide⁵⁷. Primary among these services is the reduction of coastal risks through the attenuation/dissipation of wave energy, breaking of offshore waves, slowing of inland water transfer⁵⁸, and sediment stabilization⁵⁹. These functions protect people and infrastructure from coastal risks like tsunamis, storm surges, high wind and wave velocity, and other such extreme events. The ecosystem service of risk reduction is especially important as communities dependent on coastal ecosystems expand. The risks to coastal communities are projected to increase with changes in climate. Coastal systems and low-lying areas will increasingly experience adverse impacts brought on by climate change such as submergence, coastal flooding, and coastal erosion due to relative sea-level rise⁶⁰. Changes in storms, strong wave and high wind velocity events and storm surges may further contribute to an increase in the hazards faced by coastal communities. Policy can play a key role in protecting ecosystem services, but can only do so effectively if an ecosystem services framework is integrated into environmental law and policy. Such a framework can provide a mechanism for ensuring that decision-makers fully consider the consequences of choosing between physical development and environmental protection⁶¹. While integrating the ecosystem services concept into environmental law and policy is largely an accepted end, an essential initial step is to acquire a thorough understanding of current legislative and policy recognition of ecosystem services, to determine key gaps and trends.

My analysis of risks faced by coastal areas in India showed that threats faced by the states on the eastern coast of India are very high and the coping capacity of these states is low. This would exacerbate the impact of extreme events in these states. States like West Bengal, Orissa and Andhra Pradesh face the highest coastal risks and have low capacity to weather them. Further, geospatial analysis shows that natural coastal ecosystems have declined over the last two decades and urbanization is occurring at a very fast pace, at the expense of these natural ecosystems. Coastal populations have also increased, further increasing exposure to coastal risks. These risks necessitate a robust policy that would put in place specific measures that addresses the deterioration of the protections that natural coastal ecosystems provide. This is especially important as climate change is increasing the risks to coastal areas.

Identifying the key deficiencies within the existing legal framework is the first step towards structural change. Acquiring an appreciation of the current legislative and policy recognition of ecosystem services would lead to an understanding of key gaps and trends. Based on the shortcomings and lacunae in NAPCC 2008 and CRZ 2019 to address threats to coastal risk reduction, I have proposed a number of recommendations. I have suggested modifications/inclusions that would counter coastal risk reduction in the face of climate change which are discussed in the succeeding paragraphs.

NAPCC 2008

NAPCC 2008 already contains a “mission” for combating the effects of climate change on an ecosystem, the Himalayan ecosystem. Hence, to recognize the fact that coastal regions are vulnerable to sea level rise, increased surface temperature, increased storm intensity and frequency, and wave size and direction due to climate change, a new mission on the coastal ecosystem needs to be incorporated into the NAPCC 2008. Some of the specific initiatives that could be included in the **National Mission for Coastal Ecosystems** are discussed below.

- Conduct vulnerability assessments^{iv} of the entire coastline (areas, ecosystems and population) at regular intervals, and integrate them into decision-making about coastal ecosystems.
- Scientific monitoring, at regular intervals, of long term trends relating to increasing inundation probabilities, probability of intense storms and wind/wave velocity events, erosion, can be used to assess the magnitude of risks. High risks can then be addressed in specific coastal plans.
- Undertake coastline mapping at regular spatial and temporal intervals, by means of mapping tools that visually displays the geology of India's coastline. Different features along the coast like beaches, salt marshes, dunes, are dynamic in nature, changing through time and space. Precise information is required for the design of conservation measures for the natural features of the coast, coastal protection, preparation of hazard zones, formulation of policies, and regulation of coastal developmental activities.
- Promote the use of nature-based solutions to maintain coasts. Conservation and restoration of coral reefs, mangroves, etc., managed coastal realignment^v, creation of marsh sills, living reefs/oyster reefs, and rock breakwaters can be used to protect coastlines so that they continue to reduce coastal risks.
- Initiate community-based land-use planning in coastal areas, especially in coastal common lands and use public hearings for all projects proposed in these areas. This will ensure development activities in the coastal areas do not undermine initiatives undertaken for ecosystem management.
- Integrating ecosystem-centric approaches to climate change adaptation into all government and private sector policies, plans, and budgets.

CRZ 2019

I have suggested several specific measures in CRZ 2019 that flow from the analysis of CRZ 2019 discussed in the previous section of this thesis. The detailed parameters for analysis as well as the recommendations associated with them have been mapped in **Appendix 1** (column 4). All of these measures can help ensure that coastal ecosystems continue to provide risk reduction, in the face of climate change and other threats/pressures.

Drivers

Climate related drivers affecting coastal risk reduction need to be identified by means of drawing hazard line⁶², drawing setback lines⁶³ or by means of any other climate vulnerability assessments. These tools could be linked to the planning process by restricting any development in the hazard areas identified.

Pressures

Identification of the exact pressures like changes in land use, alteration of bathymetry of coastal waters, mining, and assessment of their magnitude will enable the Environment Ministry to incorporate specific measures in the CRZ policy to lessen their impact. Ecological carrying capacity^{vi} could be used as an input to Strategic Environment Assessment (SEA)/Environment Impact Assessment (EIA) for projects and plans in the coastal areas.

^{iv} Many methods to assess vulnerability of coastal areas to climate change exist like index-based methods, indicator-based approach, GIS-based decision support systems, and methods based on dynamic computer models.

^v Conversion of historically reclaimed land into marshes for coastal defense

^{vi} The ecological carrying capacity is maximum population that the coastal areas can support sustainably and is calculated by taking into account the rate of growth of population and change in population size over time.

State

Various tools^{vii} are available for modeling the capacity for coastal risk reduction. These may be used to arrive at an assessment of current state as well as state in the future, taking into account the impacts of climate change.

Impacts

Spatial modelling of the **impacts** of climate change on coastal risk^{viii} (sea-level rise, storm surges, tsunamis, and high wind/wave events) can be done in the form of a dashboard, accessible to all. This can provide support in making decisions about conserving ecosystems and coastal communities in the light of increasing risks. This tool can also be used in creating Land Use Norms for the different zones in the coastal areas as well as for conducting SEA/EIA for development projects in the coastal areas.

Response

(i) Management strategy: Clearly articulate the coastal management strategy (e.g. Integrated Coastal Area Management, Integrated Coastal Zone Management, Adaptive Management, Marine Spatial Planning, Ecosystem Based Management, fisheries management) followed for the conservation of the coastal areas and the ecosystem services it provides. This will clarify goals, measures, and indicators required in the policy to sustain the long term health of the coastal areas and the ecosystem services it provides, especially in light of the impacts of climate change on the coastal areas. Also, adjust the zoning strategy for the management of the coastal areas to better conserve those that are being impacted by climate change protecting the full range of benefits they provide. These could include the following:

CRZ 1: (i) Bring the land area falling between the HTL and hazard line and the land areas at least 500 m inland from the hazard line under the CRZ I classification. (ii) Subsume the inter-tidal area currently classified in CRZ 2019 as CRZ IB under CRZ I. (iii) Keep the CRZ I free from human interventions, including eco-tourism projects and road building activities. (iv) Land reclamation, dredging and other such interventions that change the bathymetry of the coastal area should be avoided in CRZ 1.

CRZ II & CRZ III: (i) CRZ II & III areas should commence from 500 m beyond the hazard line to keep the areas likely to be impacted during extreme weather events free from human disturbance. (ii) Keep the NDZ in CRZ III free from all construction projects except those required for essential services, all of which would be subject to SEA. (iii) Bar all new projects in CRZ II & III, except those that are essential for defense purposes/strategic importance.

CRZ IV: (i) Keep the coastal water in CRZ IV free from construction activities which involve dredging and land reclamation and damage the natural bathymetry of the coastal water floor/ affect sea grass and corals.

CRZ V: (i) Include in the CRZ notification as CRZ V, upland areas, consisting of development setback of at least 2 km beyond the limits of CRZ II and III.

^{vii} Ecosystem Services Assessment Tool by IPBES, tools developed by many countries like Canada and the EU as well as computer based programs like Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), Artificial Intelligence for Ecosystem Services (ARIES), Costing Nature, Ecosystem Services Toolkit (EST), Multiscale Integrated Model of Ecosystem Services (MIMES), Social Values for Ecosystem Services (SolVES), Toolkit for Ecosystem Services Site-based Assessment (TESSA)

^{viii} Like Coastal Risk Assessment Framework, InVEST

ESAs: (i) Keep existing ecosystems like mangrove, sea grass, dunes, beaches, marshes etc., free of all human intervention. There should be no permission given to any activity which has the potential to damage these ecosystems.

(ii) Identification/mapping of important areas: The following areas can be identified and mapped for inclusion in CRZ notification so that measures for their conservation and protection can be initiated: (i) Coastal resources, processes or values that are responsible for the provision of coastal risk reduction, which require protection from adverse cumulative effects; (ii) Areas open and not open for development in the coastal areas and depicted as such in the Coastal Zone Management Plan (CZMP) of each state so that development activities do not destroy the coastal ecosystems which provide coastal risk reduction; (iii) Priority areas for restoration and rehabilitation, including areas with natural character/geo-morphological features that will result in an increase the risk bearing capacity of the coastal ecosystems; (iv) Areas that are potentially affected by coastal hazards over at least the next 100 years.

(iii) Identification and prioritization of threats, analysis of tradeoffs: Measures like Coastal Vulnerability Assessments can be used to identify and map threats to the delivery of ecosystem services like coastal risk reduction on different stretches of the coast of India. These can be ranked and areas which fall under various levels of threats (areas with high, medium, low threat) can be mapped in the CZMP. Depending on the threats which are most significant, the CRZ notifications need to incorporate specific measures to reduce these threats, based on geographical location. Tradeoffs can also be analyzed and incorporated in the policy by means of ecosystem service tradeoff analysis.

(iv) Set clear goals for coastal risk reduction: Articulate an overall goal of the CRZ regulation in the CRZ 2019 notification, including an overarching vision of how best the coastal ecosystems continue to provide risk reduction in light of climate change and other pressures/threats. This needs to be done in consultation with stakeholders.

(v) Measures for combating the effect of climate change and other pressures on coastal risk reduction, and develop objective criteria to track progress: Adopt the following measures for combating the effect of climate change and other threats to coastal ecosystems, and develop objective criteria to track progress: replacement of project-based EIA in CRZ regulations by Strategic Environment Assessment (SEA); fixing of Land Use norms for the coastal areas in the CRZ regulations for ensuring that land use is carried out in line with vulnerability, hazard risks, and adaptive capacity; mapping of ecologically sensitive areas for the entire coastline, beyond the areas already in the protected area network; capping the Floor Space Index to 1991 levels to slow down the pace of urbanization; and regulating the mining of sand from coastal beaches and waters. Specific, Measurable, Achievable, Realistic, and Time-bound (SMART) indicators for each measure need to be set for assessing the impact of these measures in meeting the goals set out for them.

(vi) Create implementation structures: These structures could include allocating resources to each state to devise their own coastal management policy as the climate risks, pressures, and impacts differ from state to state; expanding and strengthening the role of public hearings; establishing science-based, independent, and continual monitoring systems for the coastal areas for ecosystem integrity and delivery of ecosystem services; regularly conducting environmental surveillance activities in the coastal areas, and giving legal or customary rights over the common lands to the coastal communities.

(vii) Define evaluation criteria for assessing impact of management strategies on climate change mediated coastal risk reduction: These can be used to limit the authorization of any upstream activities that could impact the achievement of these indicators.

It might also be useful to mention here that a single or a standalone policy or regulation rarely contains all the detailed steps and measures necessary to achieve a stated end. There could be a universe of policies within the same area that could be used to achieve a stated environment goal. Thus, it is not essential that NAPCC 2008 and CRZ 2019 contain all that I have proposed. Other policies like policies on disaster risk reduction, conservation of natural resources, and conservation of wetlands could also be used to lay down a framework to support government efforts to legislate effectively in this area.

The CRZ regulations in India have changed incrementally over the years, but the basic approach remains the same in as much as it ignores the role of science and the evidence provided by data. In this regard, there is no scientific assessment of drivers affecting the Indian coastline and the hazards they pose, there is lack of assessment of pressures and vulnerabilities which is important to counter the threats posed by the climate drivers to coastal risks. Further, risks posed by industrialization and change in land use have not been assessed and addressed. A science-based approach would also make the policy more robust, as it would more accurately reflect, and thus more clearly target, the condition and status of the coastal areas/environment resources. In the long run, this would increase the resilience of communities that are dependent on these ecosystems.

An important step in protecting the services that coastal ecosystems provide is to embed the concept of ecosystem services in environmental policies and regulations. This is not currently being done, as shown in my analysis of NAPCC 2008 and CRZ 2019. Incorporating ecosystems concept into policy would ensure that the range of benefits provided by nature are identified and measures put in place to address the threats that they face. Incorporation of the ecosystem concept can also emerge as a vehicle to heighten public appreciation of the inherent value of coastal ecosystems. This appreciation can lead the public to pressure the government to recognize the advantages of protecting certain areas from the deleterious impacts that development inevitably brings. This would be beneficial in the long term as it would result in increased sustainability of the coastal ecosystems and risk reduction that they provide. Implementing these recommendations would also minimize the impact of extreme weather events on the livelihoods and survival of millions of Indians who live in the coastal.

The two Indian policies I analyzed do not fully embrace the ecosystem services concept. However, a clearer and more direct enunciation of the ecosystems services concept will better equip policies, programs, and regulations to prevent the deterioration of coastal risk in the light of climate change. My study could be a starting point for analysis of many other ecosystems and the services they provide, like the forest ecosystems, grasslands, desert ecosystems, the Himalayan ecosystems etc. This would not only focus attention on the importance of these ecosystems and services to our wellbeing but also ensure that measures are initiated to protect those services. This will help India to become more resilient in the face of climate change by saving lives, improving health, and protecting livelihoods across the country.

References

- ¹ Pallewatta, N. (2010) 'Impacts of Climate Change on Coastal Ecosystems in the Indian Ocean Region', *Coastal Zones and Climate Change*.
- ² Mehvar, S., Filatova T., Dastgheib A., van Steveninck E.D., & Ranasinghe R. 2018. 'Quantifying Economic Value of Coastal Ecosystem Services: A Review.' *Journal of Marine Science & Engineering* 6 (1).
- ³ Daily, G. C. (2009) 'Nature's services: Society's Dependence on Natural Ecosystems'.
- ⁴ The IPBES Global Assessment on Biodiversity and Ecosystem Services, 2019, Chapter 1.
- ⁵ The General Assembly (2017) 'UN Conference on Oceans', 23(1).
- ⁶ Mehvar, S., Filatova T., Dastgheib A., van Steveninck E.D., & Ranasinghe R. 2018. 'Quantifying Economic Value of Coastal Ecosystem Services: A Review.' *Journal of Marine Science & Engineering* 6 (1).
- ⁷ Barbier EB, Hacker SD, Kennedy C, Koch EW, Stier AC, and Silliman BR. 2011. "The Value of Estuarine and Coastal Ecosystem Services." *Ecological Monographs* 81(2) (2): 169–193.
- ⁸ Pinsky, M. L., Guannel G., & Arkema K.K. 2013. 'Quantifying Wave Attenuation to Inform Coastal Habitat Conservation.' *Ecosphere* 4 (8).
- ⁹ Barbier, E. B. (2015) 'Valuing the storm protection service of estuarine and coastal ecosystems', *Ecosystem Services*, 11, pp. 32–38.
- ¹⁰ Mcivor, A. Möller I., & Spencer T., 2012. 'Reduction of Wind and Swell Waves by Mangroves'. *Natural Coastal Protection Series: Report 1 Cambridge Coastal Research Unit Working Paper 40*, 1–27.
- ¹¹ Guannel, G., Arkema K., Ruggiero P., & Verutes G. 2016. 'The Power of Three: Coral Reefs, Seagrasses and Mangroves Protect Coastal Regions and Increase Their Resilience.' *PLoS ONE* 11 (7): 1–22.
- ¹² Costanza R., Martinez L.M., Sutton P., Anderson S.J., & Kenneth. 2008. 'The Value of Coastal Wetlands for Hurricane Protection.' *Journal of the Human Environment* 37 (4): 241–48.
- ¹³ Narayan, S., Beck M.W., Reguero B.G., Losada I.J., Van Wesenbeeck B., Pontee N., Sanchirico J.N., Ingram J.C., Lange G.M., & Burks-Copes K.A. 2016. 'The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences.' *PLoS ONE* 11 (5): 1–17.
- ¹⁴ Quartel, S., Kroon A., P. Augustinus G.E.F., Van Santen P., & Tri N.H. 2007. 'Wave Attenuation in Coastal Mangroves in the Red River Delta, Vietnam.' *Journal of Asian Earth Sciences* 29 (4): 576–84.
- ¹⁵ Krauss, K.W., Mckee K.L., Lovelock C.E., Cahoon D.R., Saintilan N., Reef R., & Chen L. 2014. 'How Mangrove Forests Adjust to Rising Sea Level.' *New Phytologist* 202 (1): 19–34.
- ¹⁶ Pachauri, R.K. & Meyer L.A. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Geneva, Switzerland, 2014
- ¹⁷ Climate Change Science Program 2009

-
- ¹⁸ Powell, E.J., Tyrrell M.C., Milliken A., Tirpak J.M., & Staudinger M.D. 2019. 'A Review of Coastal Management Approaches to Support the Integration of Ecological and Human Community Planning for Climate Change.' *Journal of Coastal Conservation* 23 (1).
- ¹⁹ Church, J. A. & Clark P.U. *Sea level change. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*
- ²⁰ Hemer, M. A., Fan Y., Mori N., Nobuhito S., Semedo A., & Wang X.L.(2013) 'Projected changes in wave climate from a multi-model ensemble', *Nature Climate Change*, 3(5).
- ²¹ Vousdoukas, M. I. et al, 'Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard'. *Nat. Commun.* (2018). Mori, N. et al. 'Future changes in extreme storm surges based on mega-ensemble projection using 60-km resolution atmospheric global circulation model'. *Coast. Eng. J.* (2019).
- ²² Wong, P. et al. Coastal Systems & Low-Lying Areas in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC (2014). Ranasinghe, R. 'Assessing climate change impacts on open sandy coasts: A review'. *Earth-Science Rev.* (2016). Cazenave, A. et al. 'Sea level rise and its coastal impacts'. *Earth's Future* (2014).
- ²³ He, Q. & Silliman B.R., 2019. 'Climate Change, Human Impacts, and Coastal Ecosystems in the Anthropocene.' *Current Biology* 29 (19)
- ²⁴ Govt, India. 2019. *India Year Book 2020*. Vol. 53.
- ²⁵ Neumann, B., Vafeidis A.T., Zimmermann J., & Nicholls R.J. et al. (2015) 'Future coastal population growth and exposure to sea-level rise and coastal flooding - A global assessment', *PLoS ONE*, 10(3).
- ²⁶ Garg, A, Shukla P.R., & Kapshe M. 2007. 'From Climate Change Impacts to Adaptation: A Development Perspective for India.' *Natural Resources Forum* 31 (2): 132-41.
- ²⁷ Sathaye, J., Shukla P.R., & Ravindranath N.H. (2006) 'Climate change, sustainable development and India: Global and national concerns', *Current Science*.
- ²⁸ Rao, A. D., Upadhaya P., Ali H., Pandey S., & Warriar V.(2020) 'Coastal inundation due to tropical cyclones along the east coast of India: an influence of climate change impact', *Natural Hazards*. Springer Netherlands, 101(1), pp. 39-57.
- ²⁹ Kay S, J. Caesar J., Wolf L., Bricheno L., Nicholls R.J., Saiful Islam A.K.M., Haque A., Pardaens A., & Lowe J.A. (2015) 'Modelling the increased frequency of extreme sea levels in the Ganges-Brahmaputra-Meghna delta due to sea level rise and other effects of climate change', *Environmental Sciences: Processes and Impacts*. Royal Society of Chemistry, 17(7)
- ³⁰ Mendelsohn, R. et al. (2012) 'The impact of climate change on global tropical cyclone damage', *Nature Climate Change*, 2(3). Rahmstorf, S. (2017) 'Rising hazard of storm-surge flooding', *Proceedings of the National Academy of Sciences of the United States of America*, 114(45). Vitousek, S. et al. (2017) 'Doubling of coastal flooding frequency within decades due to sea-level rise', *Scientific Reports*, 7(1).
- ³¹ Gazette of India: Extraordinary—Ministry of Environment. Forest and Climate Change, G.S.R. 37(E), 2019

-
- ³² Welle T., Beck M.W., & Birkmann J. (2012) ‘Coasts at Risk’, in *Coastal Research Library*.
- ³³ Welle T., Beck M.W., & Birkmann J. (2012) ‘Coasts at Risk’, in *Coastal Research Library*.
- ³⁴ <https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=form>
- ³⁵ IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—coastal systems and low-lying areas)
- ³⁶ IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—coastal systems and low-lying areas)
- ³⁷ Rappaport D. & Friend A., “Towards a comprehensive framework for environmental statistics : a stress-response approach”(1979)
- ³⁸ IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—coastal systems and low-lying areas)
- ³⁹ Teixeira, H., Borja A., & Elliott M. 2014. “European Commission: D E V O T E S: Recommendations for the implementation of the Marine Strategy Framework Directive” October 2014.
- ⁴⁰ Eliot et al. “*Force majeure*: Will climate change affect our ability to attain Good Environmental Status for marine biodiversity?” Marine Pollution Bulletin June 2015
- ⁴¹ IPCC Report-- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report (Chapter 5—coastal systems and low-lying areas)
- ⁴² A systems approach to policy analysis and development planning: Construction sector in the Turkish 5-year development plans (Oner, et al.)
- ⁴³ P. Checkland, Systems Thinking, Systems Practice
- ⁴⁴ A. Hwang: Toward fostering systems learning in organizational contexts, Syst. Pract. Action Res. 13 (3) (2000) 329-343
- ⁴⁵ System approach for coastal zone management: Application in southeast coast of Terceira Island and Guadiana estuary. *M.h. Guimarães, A. Mascarenhas, C. Sousa, T. Dentinho & T. Boski*
- ⁴⁶ Lundqvist, L. J. (1996) ‘Environmental Politics in the Nordic Countries: Policy, Organization, and Capacity’, in P. M. Christiansen (ed.) *Governing the Environment: Politics, Policy, and Organization in the Nordic Countries* 5, pp. 13-27. Copenhagen: Nordic Council of Ministers., ⁴⁶ Goals, Instruments, and Environmental Policy Choice; ⁴⁶ The evaluation of climate policy: theory and emerging practice in Europe, 2011; A Framework for Evaluating Environmental Policy Instruments Context and Key Concepts-- A goal oriented indicator framework to support integrated assessment of new policies for agri-environmental systems (Olssen et al; A systems approach to policy analysis and development planning: Construction sector in the Turkish 5-year development plans (Oner, et al.); ⁴⁶ P. Checkland, Systems Thinking, Systems Practice; ing systems learning in organizational contexts, Syst. Pract. Action Res. 13 (3) (2000) 329-343; ⁴⁶ System approach for coastal zone management: Application in southeast coast of Terceira Island and

Guadiana estuary: *M.h. Guimarães, A. Mascarenhas, C. Sousa, T. Dentinho & T. Boski*⁴⁶ A Framework for Evaluating Environmental Policy Instruments: Context and Key Concepts-- Per Mickwitz

⁴⁷ A Framework for Evaluating Environmental Policy Instruments Context and Key Concepts

⁴⁸ A goal oriented indicator framework to support integrated assessment of new policies for agri-environmental systems (Olssen et al)

⁴⁹ Climate Change 2014—Impacts, Adaptation and Vulnerability, IPCC, 2014 (Chapter 5—page 390- 399)

⁵⁰ A Framework for Evaluating Environmental Policy Instruments: *Context and Key Concepts*-- Per Mickwitz

⁵¹ Global Environment Outlook (UNEP, 2019)—Oceans and Coasts (Chapter 7—page 180-181)

⁵² A Handbook for measuring the progress and outcomes of Integrated Coastal Management (UNESCO, Intergovernmental Oceanographic Commission) (pg--29-33), GEO 6—UN Environment 2019 (Chapter 14-- pg--362-367)

⁵³ Elmore, 1987; Goggin *et al.*, 1990; May, 1993, 1995; Stoker, 1991

⁵⁴ Daily, G. C. (2009) ‘Nature’s Services: Society’s Dependence on Natural Ecosystems’. Island Press.

⁵⁵ Costanza, R., d’Arge R., de Groot R., Farberk S., Grasso M., Hannon B., Limburg K., Naeem S., O’Neill R.V., Paruelo J., Raskin R.G., Suttonk P., & van den Belt M. (2017 *et al.* (1998) “‘The value of the world’s ecosystem services and natural capital’”, *Ecological Economics*, 25(1).

⁵⁶ Costanza, R., de Groot R., Braat L., Kubiszewski I., Fioramonti L., Sutton P., Farber S., & Grasso M. ‘Twenty years of ecosystem services: How far have we come and how far do we still need to go?’, *Ecosystem Services*. Elsevier B.V., 28, pp. 1–16.

⁵⁷ Mehvar, S. Filatova T., Dastgheib A., de Ruyter van Steveninck E., & Ranasinghe R. (2018) ‘Quantifying economic value of coastal ecosystem services: A review’, *Journal of Marine Science and Engineering*, 6(1).

⁵⁸ Costanza, R. Pe ´rez-Maqueo O., Martinez M.L., Sutton P., Anderson S.J., & Mulder K. (2008) ‘The value of coastal wetlands for hurricane protection’, *Ambio*, 37(4), pp. 241–248.

⁵⁹ Scyphers, S. B *et al.* (2011) ‘Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries’, *PLoS ONE*, 6(8). Gittman, R. K. *et al.* (2014) ‘Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane’, *Ocean and Coastal Management*. Elsevier 102(PA). La Peyre, M. K. *et al.* (2015) ‘Assessing shoreline exposure and oyster habitat suitability maximizes potential success for sustainable shoreline protection using restored oyster reefs’, *PeerJ*, 2015(10).

⁶⁰ IPCC Assessment Report (AR) 5

⁶¹ Bell-James, J. (2019) ‘Integrating the Ecosystem Services Paradigm into Environmental Law: A Mechanism to Protect Mangrove Ecosystems?’ *Journal of Environmental Law*, 31(2), pp. 291–314.

⁶² Stevens, H. R. & Kiem, A. S. (2014) ‘Developing hazard lines in response to coastal flooding and sea level change’, *Urban Policy and Research*.

⁶³ Sanò, M. Jiménez A.J., Medina R., Stanica A., Sanchez-Arcilla A., & Trumbic I. (2011) ‘The role of coastal setbacks in the context of coastal erosion and climate change’, *Ocean and Coastal Management*. 54 (2011)

Appendix 1

Criteria (based on DPSIR)	response (0 = not addressed 1 = briefly addressed 2 = addressed in detail)	Policy analysis result	Recommendations
Column 1	Column 2	Column 3	Column 4
Were climate related drivers affecting coastal areas identified?			
severe storms	0	Climate related drivers were not identified in the policy. The policy also did not refer to any such study done by any other agency of the Government of India.	Identification of climate related drivers affecting coastal risk reduction by means of drawing hazard line, drawing setback lines or other climate tools. These tools should be linked to the planning process by restricting any development in the hazard areas identified by these tools.
extreme sea levels	0		
wind exposure	0		
wave exposure	0		
relief	0		
surge potential	0		
Were pressures faced by coastal systems identified?			
change in land use	0	Analysis of CRZ 2019 showed that only some pressures like pollution, impacts due to setting up industries, mining, and infrastructure activities have been identified. Other pressures on the coastal ecosystems like construction of engineered coastal defense projects, changes in bathymetry due to dredging, changes in coastal land use, and deforestation have not been identified in CRZ 2019.	Identification of the exact pressures like changes in land use, alteration of bathymetry of coastal waters, mining, and their magnitude will enable the Environment Ministry to incorporate specific measures in the CRZ policy to lessen their impact. Ecological carrying capacity could be used as an input to Strategic Environment Assessment (SEA)/Environment Impact Assessment (EIA) for projects and plans in the coastal areas.
deforestation	0		
alterations in bathymetry	0		
mining on beaches/corals	1		
infrastructure works	1		
coastal defense works	0		
	0		
Were current and future state assessed?			
assessment of flood control services	0	Analysis of CRZ 2019 showed that the current or the future status of ecosystems and services, except a small reference to the need for maintaining the coastal ecosystems, was not referred to in the policy.	Various tools ¹ are available for modeling the capacity for coastal risk reduction. These may be used to arrive at an assessment of current state as well as state in the future, taking into account the impacts of climate change.
storm surge	0		
wind energy	0		
wave energy	0		
SLR	0		
relief	0		
extent of maintenance of ecosystems	1		
Were impacts evaluated?			
<i>biophysical impacts</i>			
flood damage	0	Some impacts on ecosystems like impacts on mangroves, coral reefs, and sand dunes were referred to. Biophysical impacts like flood damage, submergence (specifically reefs, barrier islands), shoreline erosion, dryland loss due to erosion, wetland loss and change have not been mentioned. These	Spatial modelling of the impacts of climate change on coastal risk ² (sea-level rise, storm surges, tsunamis, and high wind/wave events) can be done in the form of a dashboard, accessible to all. This can provide support in making decisions about conserving ecosystems and coastal communities in the light of increasing risks. This tool can also be
submergence of drylands (reefs, barrier islands, shorelines)	0		
dryland loss due to erosion	0		
wetland loss and change	0		

¹ Ecosystem Services Assessment Tool by IPBES, tools developed by many countries like Canada and the EU as well as computer based programs like Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), Artificial Intelligence for Ecosystem Services (ARIES), Co\$ting Nature, Ecosystem Services Toolkit (EST), Multiscale Integrated Model of Ecosystem Services (MIMES), Social Values for Ecosystem Services (SolVES), Toolkit for Ecosystem Services Site-based Assessment (TESSA)

² Like Coastal Risk Assessment Framework, InVEST

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Criteria (based on DPSIR)	response (0 = not addressed 1 = briefly addressed 2 = addressed in detail)	Policy analysis result	Recommendations
Column 1	Column 2	Column 3	Column 4
<i>Impacts on natural systems</i>		impacts have yet to be been fully analyzed and assessed for significance.	used in creating Land Use Norms for the different zones in the coastal areas as well as for conducting SEA/EIA for development projects in the coastal areas.
rocky coasts	1		
Beaches, Sand Dunes	1		
mangroves	2		
wetland and seagrass beds	0		
Coral reefs	2		
Response			
<i>Were management strategies for coastal systems identified</i>			
watershed management	0	Analysis of CRZ 2019 shows that management strategies like watershed planning, Integrated Coastal Area Management (ICAM), Integrated Coastal Zone Management (ICZM), Adaptive Management, Marine Spatial Planning, Ecosystem Based Management (EBM), fisheries management were not reflected in the policy. CRZ 2019 contained only very limited measures of zoning and regulating activity in the coastal zones. However, it was observed that these measures contained many exemptions and permissions, which in the long run, would weaken the efficacy of the strategy. <ul style="list-style-type: none"> In CRZ 2019, CRZ 1 areas comprise the most ecologically sensitive part of the landscape (Paragraph 2) and are responsible for delivering coastal risk reduction. CRZ 2019 states that (Paragraph 5.1) generally, no activities are to be permitted in CRZ 1 areas. Analysis of these provisions show that many exemptions are provided (Paragraph 5) and some activities are permitted after an approval process. "Eco-tourism" constructions and activities are allowed (5.1.1.iii) as is mining for rare earth minerals in sand dunes (5.1.2.xii), transfer of hazardous substances from ships to ports, terminals and refineries (5.1.2. iv), maintenance and clearing of 	Clearly articulate the coastal management strategy (e.g. Integrated Coastal Area Management, Integrated Coastal Zone Management, Adaptive Management, Marine Spatial Planning, Ecosystem Based Management, fisheries management) followed for the conservation of the coastal areas and the ecosystem services it provides. Also, adjust the zoning strategy for the management of the coastal areas to better conserve the coastal areas that are being impacted by climate change so that the full range of benefits they provide can be ensured in the long term. These could include the following. <ul style="list-style-type: none"> CRZ 1: (i) Bring the land area falling between the HTL and hazard line and the land areas at least 500 mts inland from the hazard line under the CRZ I classification. (ii) Subsume the inter-tidal area currently classified in CRZ 2019 as CRZ IB under CRZ I. (iii) Keep the CRZ I free from human interventions, including eco-tourism projects and road building activities. (iv) Land reclamation, dredging and other such interventions which change the bathymetry of the coastal area should be avoided in CRZ 1. CRZ II & CRZ III: (i) CRZ II & III areas should commence from 500 mts beyond the hazard line to keep the areas likely to be impacted during extreme weather events free from human disturbance. (ii) Keep the NDZ in CRZ III free from all kinds of construction except those required for essential services, all of which would be subject to SEA. (iii) Bar all new projects
ICAM (Integrated Coastal Area Management)	0		
adaptive management	0		
ICZM	0		
marine spatial planning	0		
marine protected areas/ coastal areas falling within the PA network	0		
EBM	0		
system of zoning	1		

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Criteria (based on DPSIR)	response (0 = not addressed 1 = briefly addressed 2 = addressed in detail)	Policy analysis result	Recommendations
Column 1	Column 2	Column 3	Column 4
		<p>waterways, channels (5.1.2.i.e), and waste treatment in sensitive inter-tidal areas (5.2.ix). Construction of roads on stilts is also allowed for defense, strategic purposes, and public utilities (5.1.1.iii) & 5.1.2.i.c) and what is strategic has not been defined. Damage to mangroves is allowed as long as compensatory plantation of mangroves takes place for which no process has been specified. ed. Further, land reclamation (Paragraph 5.1.2.i), which is known to have strong impacts on coastal ecology, has been allowed in intertidal or CRZ-IB areas, for ports and sea links. These exemptions might reduce the coastal protection services provided by the ecosystem and makes the area more vulnerable to the impacts of climate change.</p> <ul style="list-style-type: none"> The 2019 notification also provides for “construction of memorials or monuments and allied facilities in exceptional cases” in CRZ-IVA areas which includes the “water area and the sea bed area between the low tide line up to 12 nautical miles on the seaward side”. This will affect the fragile coastal ecosystems, particularly because it would involve land reclamation, dredging in the coastal waters etc. 	<p>in CRZ II & III, except those that are essential for defense purposes/strategic importance.</p> <ul style="list-style-type: none"> CRZ IV: (i) Keep the coastal water in CRZ IV free from construction activities which involve dredging and land reclamation and damage the natural bathymetry of the coastal water floor/ affect sea grass and corals. CRZ V: (i) include in the CRZ notification as CRZ V, upland areas, consisting of development setback of at least 2 km beyond the limits of CRZ II and III. ESAs: (i) Keep existing ecosystems like mangrove, sea grass, dunes, beaches, marshes etc., free of all human intervention. There should be no permission given to any activity which has the potential to damage these ecosystems
<i>Were important areas responsible for delivery of CRR identified and mapped?</i>			
mapping of the landward extent of the coastal environment,	1	<ul style="list-style-type: none"> In CRZ 2019, the coastal areas of India were divided into Coastal Regulation Zones I, II, III & IV. However, this zoning extended to only to a maximum of 200 mts from the HTL. Zoning was done for only this very narrow strip of land. Coastal ecology and the delivery of coastal risk reduction extends beyond this 	<p>The following areas can be identified and mapped for inclusion in CRZ notification so that measures for their conservation and protection can be initiated: (i) Coastal resources, processes or values that are responsible for the provision of coastal risk reduction, which require protection from adverse cumulative effects; (ii) Areas open and not open for development in the coastal areas and depicted as such in the Coastal Zone</p>
Important areas for preserving and protecting natural features landscapes of the coastal environment	2		
Coastal resources, processes or values	1		

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Criteria (based on DPSIR)	response (0 = not addressed 1 = briefly addressed 2 = addressed in detail)	Policy analysis result	Recommendations
Column 1	Column 2	Column 3	Column 4
which require protection from adverse cumulative effects		minimal distance in many places and includes upland areas. These areas were not identified and mapped.	Management Plan (CZMP) of each state so that development activities do not destroy the coastal ecosystems which provide coastal risk reduction; (iii) Priority areas for restoration and rehabilitation, including areas with natural character/geo-morphological features that will result in an increase the risk bearing capacity of the coastal ecosystems; (iv) Areas that are potentially affected by coastal hazards over at least the next 100 years.
Areas of the coastal environment where particular activities and forms of subdivision, use and development are inappropriate	0	<ul style="list-style-type: none"> • There was no mapping of areas open or closed to development. • The policy called for mapping of ecologically sensitive areas which had already been previously identified under the Protected Area network. 	
Areas of the coastal environment where activities are to be provided for including urban development, aquaculture and the operation of ports	1	<ul style="list-style-type: none"> • CRZ 2019 did not have any provisions for the identification and mapping of areas important for the delivery of ecosystem services or for priority areas on the coast that required restoration and rehabilitation. 	
Priority areas for restoration and rehabilitation	1		
Areas which are potentially affected by coastal hazards over at least the next 100 years	0		
<i>Were threats mapped and prioritized and tradeoffs identified in the policy?</i>			
<i>threats</i>			
biophysical threats identified (flood damage, submergence of drylands (reefs, barrier islands, shorelines), dryland loss due to erosion, wetland loss and change)	0	CRZ 2019 did not identify threats to the coastal areas which would impair their ability for risk reduction. It also did not contain measures to reduce threats like inundation, submergence of drylands, dryland loss due to erosion, wetland loss and change. It also did not incorporate	Measures like Coastal Vulnerability Assessments can be used to identify and map threats to the delivery of ecosystem services like coastal risk reduction on different stretches of the coast of India. These can be ranked and areas which fall under various levels of threats (areas with high, medium, low threat) can be mapped in the CZMP. Depending on the threats which are most significant, the CRZ notifications need to incorporate specific measures to reduce these threats, based on geographical location.
threats to natural systems (rocky coasts, Beaches, Barriers, and Sand Dunes, mangroves, wetland and sea grass beds, coral reefs, coastal aquifers, estuaries and lagoons, deltas, fisheries)	1	measures to reduce threats to human systems like settlements, infrastructure, industries, agriculture etc. Analysis of CRZ 2019 showed that many provisions in CRZ 2019 increased threats to coastal ecosystems like the provision allowing for a relaxation of floor space index for buildings in CRZ II which allows construction close to shoreline. This would increase urbanization	

Appendix 1

Criteria (based on DPSIR)	response (0 = not addressed 1 = briefly addressed 2 = addressed in detail)	Policy analysis result	Recommendations
Column 1	Column 2	Column 3	Column 4
		and construction of high rises, very near the coast. In the intertidal areas, CRZ 2019 allows for construction closer to the water areas (between 50 m to 200 m from HTL) which would increase threats to infrastructure as well as human settlements. These threats were also not prioritized on the basis of severity.	
<i>tradeoffs</i>			
were CRR valued in terms of societal, economic and ecosystem benefits	0	Tradeoffs among different measures were also not incorporated in CRZ 2019.	Tradeoffs can also be analyzed and incorporated in the policy by means of ecosystem service tradeoff analysis.
were explicit tradeoffs with stakeholders weighted	0		
were disputes among sectors resolved	0		
was a consensus formed on best choices and expected results of those choices	0		
<i>Were clear goals regarding risk reduction set in the policy</i>			
Was a consensus-based process to formulate a shared set of goals created?	0	CRZ 2019 includes an introduction which stated that the coastal areas are regulated into zones “with a view to conserve and protect the unique environment of coastal stretches and marine areas, besides livelihood security to the fisher communities and other local communities in the coastal areas and to promote sustainable development based on scientific principles taking into account the dangers of natural hazards, sea level rise due to global warming”. Analysis of CRZ 2019 showed that the regulation mentioned issues like conservation of coastal areas, livelihood security, sustainable development, and the danger posed by natural hazards. However, there was no mention in the regulation about the protection of ecosystem services like coastal	Articulate an overall goal of the CRZ regulation in the CRZ 2019 notification, including an overarching vision of how best the coastal ecosystems continue to provide risk reduction in light of climate change and other pressures/threats. This needs to be done in consultation with stakeholders.
Were environment goals set for sustainability of coastal ecosystems (water quality, control over degradation of coastal ecosystems, control over erosion, maintenance of biodiversity, control over alteration of relief/ bathymetry)	1		
Were measures for sustainable development of coastal areas identified?	1		

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		<p>risk reduction, stakeholder consultation, quality of life of the coastal communities, and preservation of biodiversity of the coastal areas. Detailed analysis of the policy also indicated that the goals mentioned in the statement of intent were not fully translated into actual policy measures in CRZ 2019 as discussed below:</p> <ul style="list-style-type: none"> • Analysis showed that for CRZ II, the older notification (2011) had frozen the Floor Space Index (FSI) at 1991 levels. CRZ 2019 has relaxed this and permitted a higher FSI for construction projects. Also, certain kinds of buildings in metro cities such as Chennai and Mumbai have been exempted from meeting the conditions required for construction in CRZ II areas in CRZ 2019. This would allow for more building activity and urbanization in the coastal areas, stressing the fragile coastal ecosystem. This would also magnify risks due to threat in delivery of coastal risk reduction as development is permitted close to shoreline. • CRZ 2019 labels land along “tidal influenced water bodies” as No Development Zone (NDZ) in CRZ III areas. NDZ is the area where no developmental activities can take place. In CRZ 2019, the NDZ has been reduced from 100 m (in CRZ 2011) to 50 m or the width of the creek, whichever is less, in densely populated rural areas. In less populated rural areas, the NDZ has also been reduced from 200 m to 50 m. Further, prohibition on construction has been lifted in NDZ. Temporary tourist facilities, gardens/ parks, agriculture, forestry, pastures, playfields, roads, community toilets, schools, 	

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		<p>drainage/ sewerage facilities, will be allowed. Also, on landward sides of roads in NDZ, construction of resorts, hotels, and associated tourism facilities shall be permitted. Mining of rare minerals has also been allowed.</p> <ul style="list-style-type: none"> Increased activity in the coastal areas, which has now been permitted, would allow more urbanization, encourage more tourism-related activities, and enable other development. 	
<i>Were measures introduced for preserving ecosystems to reduce the threats of climate change/other threats and quantitative objectives set to measure progress</i>			
<i>sustainability of coastal ecosystems</i>		<p>CRZ 2019 contained some measures to combat the effects of climate change and the pressures on coastal areas, but no indicators were specified to assess whether these measures were having the intended effects. No measures relating to ensuring sustainability of coastal livelihoods, sustainable development of coastal areas, reducing vulnerability of coastal areas, and ecosystem services in light of climate change were included.</p> <ul style="list-style-type: none"> Analysis showed that CRZ 2019 contained interventions like conservation of mangroves, sand dunes, seagrass, coral reefs etc., however, these interventions were not complete as many activities (tourism related, port facilities, projects with strategic interest) were allowed in the areas that contained the above-mentioned ecosystems. Further, there were no measurable indicators included in the policy that could be used to arrive at a conclusion regarding whether these interventions resulted in desired results. For sustainable development of the coastal areas, a system of zoning was incorporated and measures to regulate activities in 	<p>Adopt the following measures for combating the effect of climate change and other threats/pressures on coastal ecosystems, and develop objective criteria to track progress: replacement of project-based EIA in CRZ regulations by Strategic Environment Assessment (SEA); fixing of Land Use norms for the coastal areas in the CRZ regulations for ensuring that land use is carried out in line with vulnerability, hazard risks and adaptive capacity; mapping of ecologically sensitive areas to the entire coastline, beyond the areas already in the protected area network; capping the Floor Space Index to 1991 levels to slow down the pace of urbanization; and regulating the mining of sand from coastal beaches/coastal waters. Specific, Measurable, Achievable, Realistic, and Time-bound (SMART) indicators for each measure need to be set for assessing the impact of these measures in meeting the goals set out for them.</p>
% of mangroves/sand dunes/beaches/sea grass beds/coral reefs/non mangrove forests/salt marshes/wetlands maintained/increased per year	0		
% of shoreline erosion prevented per year	0		
% of rock sills and other artificial breakwaters in front of tidal marshes created along energetic estuarine shores per year	0		
<i>sustainable development of coastal areas</i>			
% of land use permits/zoning for industries, infrastructure, aquaculture, agriculture, settlements received but refused due to location in coastal area, per year	0		
% of refusals of proposals for mining per year	0		

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% of area of coastal water kept free by controlling activities that affect bathymetry of the sea like dredging, deep sea mining, desilting etc. per year	0	<p>these zones were included in CRZ 2019. Measurable criteria, however, like land use permits/zoning for industries/ infrastructure projects received but refused due to location in coastal areas etc., were not formulated.</p> <ul style="list-style-type: none"> No measures were incorporated in the CRZ 2019 for ensuring sustainable quality of life of the coastal community, especially in light of increase of coastal risks due to climate change. 	
no of permits received and refused for extraction of gravel and sand from beaches, per year	0		
no of EIA conducted for projects including industries, per year	0		
no of “no regret” measures initiated like adoption/ enforcement of buffer zones and coastal development setbacks	0		
<i>Were implementation structures for mitigating the impact of climate change on coastal areas and the services they provide created</i>			
sustainability of initiative	1	<p>Analysis of CRZ 2019 showed that a limited attempt was made to align the management structure with the chosen management strategy –zoning and regulation of activity in the coastal areas. While sustainability of the initiative is high as CRZ 2019 is a government regulation, No separate mechanism for funding initiatives for the coastal areas was specified and traditional rights of the fisher folk was not guaranteed approved by the central government. CRZ 2019 contained a coordinating agency called the Coastal Zone Management Authority at the level of the state (as in the earlier regulations of 1991 & 2011). . Opportunities for stakeholder consultation were few. Other provisions, like consulting the traditional fishing community for construction of dwelling units or requiring a public hearing for</p>	<p>These could include allocating resources to each state to devise their own coastal management policy as the climate risks, pressures, impacts from climate change on the coastal areas differs from state to state; Expand and strengthen the mechanism of public hearing; Set up science based independent and continual monitoring system for the coastal areas; Environment surveillance activities in the coastal areas should be done regularly and Legal/customary rights over the common lands may be given to the coastal communities.</p>
separate funding mechanisms with controls	2		
involvement of stakeholders like local communities/NGOs/ research agencies/ regional/local management initiatives along with traditional rights	0		
coordinating agency	1		
stakeholder consultation	1		
monitoring arrangements and independence	1		
improved surveillance methods	0		
development of norms, standards	0		

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		specific projects in the CRZ area have also been omitted from CRZ 2019. CRZ 2019 does not contain any provisions for setting up independent monitoring. No environmental surveillance methods are mentioned in the policy.	
<i>Were evaluation criteria for assessing impact of management strategies defined and set</i>			
Coastline stabilization and protection from hazard	0	No outcome indicators were defined for coastline stabilization and protection from hazards, coastal development, and participation of coastal community. Hence, the government would find it difficult to assess whether CRZ 2019 was delivering the desired outcomes and whether the policy succeeded in reducing the risks the coastal areas face.	Define evaluation criteria for assessing impact of management strategies on climate change mediated coastal risk reduction: These can be used to limit the authorization of any upstream activities that could impact the achievement of these indicators
Coastal sustainable development	0		

Land Cover Difference Raster between 1992 and 2018 India Mainland Coastline (10 Km wide swathe)

