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COASTAL RESOURCES, ECOSYSTEM SERVICES AND DISASTER RISK REDUCTION

An Analysis of Social and Environmental Vulnerability along the Coast of India

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Introduction

The Indian sub-continent is more prone to coastal hazards. Statistics show that the Indian coast has been hit by 92 storms between 1980 and 2010 (Miththapala, 2012). And its impact can be felt by more than three-fourth of the country's population that is settled along the coast. With the rapid increase in the pace of urbanisation and infrastructural development along the coast, the impact of coastal hazards are set to rise and the risks associated with it are often unpredictable. Coastal hazards can be understood in terms of its temporal nature namely discrete coastal events and those due to continuing changes over the long period (Table 1). There are 84 coastal districts affected by tropical cyclones in India, out of which the states of Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Puducherry and Gujarat are more vulnerable to cyclones (NCRMP, 2010).

Table 1. Type of Coastal Hazards

Discrete coastal events	Continuing changes over the long term
Severe waves	Relative sea-level change
Storm surges	Coastal erosion
Tsunami	Saline intrusion
Coastal earthquakes	

Source: Arthurton (1998).

Studies show that coastal hazards have tremendously increased the vulnerability of the population living below the poverty line (Rego et al, 2010). Apart from ensuring a sustenance source of livelihood, a significant function of the coastal ecosystem services has been storm/flood protection, climate regulation, waste processing, and erosion control (Ranganathan et al, 2008). However, with the depletion of coastal ecosystems, scientific projections demonstrate that factors such as climate change can also create large scale social and economic impacts on the population dependent coastal ecosystem services for their livelihoods (Table 2).

Table 2. Socio-economic Impact on Coastal Ecosystems

	More frequent floods	Erosion of coast	Inundation by sea water	Rise in water table	Intrusion of salt water	Changes in biological processes
Water Resources			√	√	√	√
Agriculture	√		√	√	√	
Human Health	√		√			√
Fisheries	√	√	√		√	√
Tourism	√	√	√			√
Human Settlements	√	√	√	√		

Source: UNFCCC, 2006

Coastal ecosystems across the world are facing a huge risk of degradation due to anthropogenic interventions. According to the World Ocean Network, 69 percent of the coastal ecosystems in Asia are facing severe risk of degradation due to ill-conceived infrastructural development and pollution. Rapid economic and industrial growth along the

coast, the spread of agricultural activities into wetlands that once acted as natural drains, ad-hoc construction of buildings, unscientific and poorly planned structural mitigation strategies, accompanied by marked increase in population density have had a cumulative impact on coastal hazard risks. The lack of integration and regulation of diverse coastal development activities, rise in resource-use conflicts, overexploitation of coastal and marine resources, resulting ecological and livelihood uncertainties and social vulnerabilities act as dynamic pressures and unsafe conditions in the manifestation of risk.

Preliminary investigation along the coastal districts of India has shown that the coastal ecosystems are threatened by various factors. Coastal ecosystems such as beaches, sand dunes, estuaries, mangroves, salt pans and reefs have been threatened by various anthropogenic intrusions. The (i) alteration to habitat conditions due to industrialisation and population growth, (ii) shoreline constructions and ill-conceived coastal engineering works, (iii) sedimentation of estuaries and river beds, (iv) shrinking of rivers and reduction in water-flow from rivers, (v) coastal dredging, (vi) coastal mining of sand for minerals, (vii) harbour development, (viii) tourism promotion and related constructions, (ix) expansion of roadways, construction of bridges and rail corridors, (x) pollution from industries, sewage and agricultural disposal, (xi) reclamation of beaches (xii) restrictions to tidal inflows due to the construction of ineffective shoreline protection structures such as sea walls, groins and breakwaters and (xiii) aquaculture are threats to the sustainability of coastal ecosystems in the country (Miththapala et al, 2012; GoI, 2007). There have been gross violations of coastal zone regulations and governance of coastal resources has been very poor (*ibid*).

This paper attempts to demonstrate the strong links between coastal development, ecosystem services and disaster risk reduction strategies. To begin with, this paper examines the trend and patterns of coastal development and coastal management practices across selected states of India namely, Kerala, Gujarat and Tamil Nadu. It then specifically analyses the implications of these development on the ecosystem services and capacities of people dependent on coastal resources for their livelihoods. This paper also critically examines the planned adaptation or structural hazard mitigation strategies that have evolved to deal with coastal hazards. The linkages between these mitigation strategies, ecosystem services and population vulnerability are further analysed. This paper is based on review of secondary sources of literature related to coastal development and planning, structural mitigation statistics and population vulnerability along the coast of India.

Planned Adaptation, Coastal Zone Management and Disaster Risk Reduction

The key assumption that this paper derives from is that 'the vicious cycle of ill-conceived development – ecosystem degradation – accelerated disasters' needs to be recognised for the effective management of the coastal and marine environment as well as in disaster risk reduction (UNISDR, 2009; Miththapala et al, 2012). The argument of this paper is that though several approaches exist to manage the coastal resources, they have failed to create a balance between development, coastal degradation and disaster risk reduction. If few approaches have emphasised on disaster risk reduction, their concern on coastal degradation has been limited. And those approaches that prioritise coastal resource

management have seldom given importance to disaster risk and vulnerability reduction. Nevertheless, all present patterns of development neglect both coastal resource management and disaster risk reduction.

Literature shows that there are mainly three main types of response strategies to coastal hazards. They are 'protect, retreat and accommodate'. Protect as a strategy consists of both hard and soft measures to arrest coastal hazards. The purpose is to protect existing assets and livelihoods from the coastal hazard. Retreat aims at shifting the population at risk to safer zones, while no measures are applied to deal with the hazard. It is basically a strategy to eliminate a direct impact. It also seeks to remove anthropogenic interventions in hazardous zones. Accommodate as a strategy aims at reducing the overall severity of damages, where human activities and hazards tend to co-exist (Gilbert and Vellinga, 1990). However, structural mitigation strategies such as the construction of sea walls and breakwaters have found to cause their own environmental problems and are very expensive as well (Latief and Hadim, 2006).

Yet another approach has been the Integrated Coastal Management (ICM). ICM is propagated as a natural resources and environment management framework that employs an integrated, interactive and holistic approach in addressing coastal issues (Thia-Eng, 2006). Though the ICM approach provides a conceptual framework for ecologically sustainable use of coastal resources, its merit has not been translated into the discourses of development planning and disaster risk reduction in India. While the ICM emphasises on close coordination and working between various stakeholders, both formal actors and traditional resource users, the challenge is making this happen. On a day-to-day livelihood and resource management struggle, the values, interests, power and knowledge of diverse actors are in conflict with one another. This itself results in the discontinuities of ICM or similar approaches.

Certain other approaches have explored how Coastal Community Resilience (CCR) as integrating framework for community development, coastal management and disaster risk reduction (US IOTWSP, 2007). The CCR framework aims at promoting a proactive approach to coastal hazards rather than a reactive focus on response to disaster events. It claims that it adopts a broad vulnerability assessment to coastal hazards, and merges goals of environmental sustainability and humanitarian assistance (*ibid*). The elements that operationalise resilience as per the CCR framework are Governance, Society and Economy, Coastal Resource Management, Land Use and Structural Design, Risk Knowledge, Warning and Evacuation, Emergency Response and Disaster Recovery. The corresponding benchmarks are policy and planning capacity, physical and natural capacity, social and cultural capacity and technical and financial capacity. Though CCR has an all-integrative approach, its recognition in the management of coastal resources has seldom been applied in the context of India. Moreover, this approach does not anticipate the historical and cumulative effects of ill-conceived development and coastal mismanagement on future resource status. In addition, On the other hand, in the Indian context, such community-based approaches in managing coastal resources are isolated projects that are short-term in nature, and do not augment efforts to integrate DRR in development planning (Krishna, 2007).

There is yet another framework that is woven around Ecosystem-based Adaptation (EbA). The EbA framework believes that this approach is more accessible to the poor than the adaptation interventions based on hard infrastructure and engineering solutions and that can be effectively built on local knowledge and needs (Miththapala et al, 2012). Illustrations under this framework narrate experiences of restoring coastal habitats such as tree walls as an elective measure against storm surges, saline intrusion and coastal erosion in Midnapur region of West Bengal, India. Other experiences include the conservation of marine ecosystems in the Gulf of Mannar and intercropping and nurturing of floating gardens in Bangladesh (*ibid*). The concept of bioshield also gained fast prominence in the post-tsunami scenario. However, in practice, it became a thoughtless act to develop vast plantations of exotic trees such as casuarinas (Shanker et al, 2008). Critics also point out to the fact that the socio-economic aspects of exotic bio-shields cloud the coastal protection functions (Feagin et al, 2010). Many of such practices also impinge upon traditional fishworkers' access to resources and sources of livelihoods as well as in the displacement of native ecosystems (Rodriguez et al, 2008). Natural buffers such as sand dunes have also been removed in some contexts (*ibid*).

Development, Coastal Zone Management and Disaster Risk Reduction in India: A Comparative Analysis

Case Analysis 1: Structural Mitigation Strategies and Coastal Development in Kerala

The present case study attempts to demonstrate how ill-conceived structural mitigation strategies such as shoreline structures can accelerate the impact of coastal hazards. Eravipuram is a fishing village in the Kollam district of Kerala. More than 320 fishing families in this village depend on inshore fisheries and venture out for fishing in their catamarans. Till some years before, *kamba vala* (shore seine) fisheries was also active in this village. Coastal hazards such as coastal erosion, coastal flooding, landward intrusion of saline ground water, episodic wave run-up, and swell waves have affected the habitat, life and livelihoods of the fish-workers in this village. The village was also affected by the Indian Ocean tsunami that struck the Kerala coast in 2004. Around 108 houses in the village were fully destroyed by the tsunami. Salination of drinking water sources are also being reported.

Our study shows that the structural mitigation strategies to avert disasters have in turn accelerated coastal hazards in this village (Santha, Forthcoming). Large-scale investments are made on seawalls, groins and breakwaters with the assumption that they could prevent coastal flooding and erosion along the Kollam coast. However, while structures such as groin could halt soil erosion at one stretch of the coast, it could accelerate erosion in the neighbouring regions. While ill-conceived groin fields could stabilise a beach on the up-drift side, they may aggravate erosion on the down-drift side. Eravipuram, which is situated between the Thankassery harbour and Paravur estuary, is one such affected village. Structures such as sea walls have increased the wave run-up height and thus accelerated erosion in the village. The present seawall that has been built to withstand coastal hazards in Eravipuram is neither able to resist surges nor reduce coastal erosion. Destruction of houses and roads due to coastal flooding and erosion has become a

regular feature along the coast of Eravipuram. Some houses close to the beach have developed cracks and are in the verge of collapsing.

Fish-workers are thus sceptical of structures like sea wall as they have not only failed to arrest coastal erosion, but also aggravated it. They believe that the risk towards coastal hazards has increased after the sea wall was built. The ad-hoc dumping of rocks has increased coastal erosion in their shore. The construction of new shoreline structures such as breakwaters in the neighbouring coast has further affected the seasonal cycle of sand flow and retention to Eravipuram. Fish-workers observe that the increase in silt deposits and dislodged boulders from seawalls have altered the habitat characteristics of their fishing grounds. They also believe that the construction of sea walls and other hard structures such as groins and breakwaters at the mouth of estuaries have affected the breeding habits of many aquatic varieties such as fish, prawns and turtles (Santha, Forthcoming). The authors' work with coastal communities show that the latter's innate capacities such as local knowledge systems in forecasting coastal hazards also get affected in such processes (*ibid*).

Coastal hazards also imply that fish-workers' access to their traditional fishing sites becomes questionable. The author's observation is that structural mitigation strategies and infrastructure development projects have prevented fish-workers in accessing their customary fishing grounds. Moreover, the instances of new types of resource-use conflicts are also rising in the region. There has also been a significant decline of the shore-seine fishery (or *kamba vala*) in the last decade. The *kamba vala* fishery, an occupation mostly by the 'retired' fish-workers required consistent monitoring and observation of fish movements by standing at the shore. However, with the construction of sea wall and subsequent loss of beach, such practices have become difficult for the elderly fish-workers.

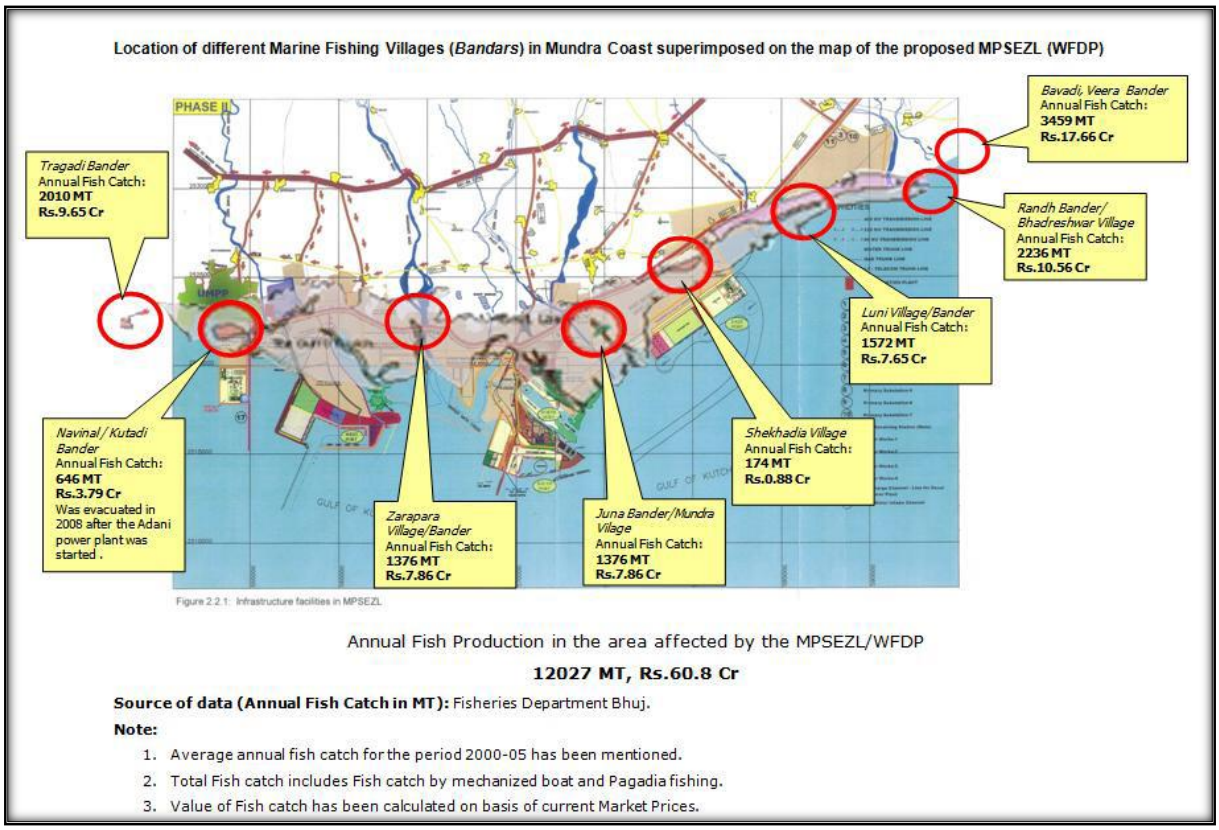
Case Analysis 2: Development, Displacement and Vulnerability along the Coast of Mundra, Gujarat

This case study attempts to analyse how the neoliberal policies and practices of development have neglected coastal zone management, sustainable livelihoods and vulnerability reduction in the pursuit of growth and profit along the Gujarat coast. Mundra is a coastal taluka in Kutch district of Gujarat. The Mundra coast is/was rich in its biodiversity, featured by unique inter-tidal mudflats, mangroves and marine life. The Mundra coastal ecosystem supports the lives and livelihoods of fishing, pastoral and farming communities, and their salt panning activity (Kohli, 2011). Oral history shows that the fishermen settled in this village some 300 years back (Patel, 2012). The *banders* (fishing grounds) in the Mundra coast of Gujarat are inhabited by the Wagher fishing community for almost eight months in a year (from September to April). Throughout this period the *bander* is the homeland of the Waghers. During the off-season most of the fishermen migrate back to their village. However, if there are certain financial requirements, families remain in the *bander* and involve in '*padadiya fishing'* (fishing by foot). The sea and the coast are part of their life and these are very integral part of their existence (Basumatary, 2014).

The Mundra coast is today impacted severely by multiple forms of industrial development projects. Studies show that there has been massive depletion of basic livelihood and ecological resources in the region (Kohli, 2011; Patel, 2012; Basumatary, 2014). Many big industrial projects including coal-based power projects, development of

ports and harbours, and Special Economic Zones (SEZs) have impacted on the quality and access to the ecological and livelihood resources that the Waghers depend upon. Activists voicing for the rights of the fishworkers provide adequate proof that land acquisition of customary resources and environmental have happened in a large scale. Figure 1 shows the location of fishing villages that are affected by industrial projects in Mundra. Nevertheless the companies coming up in the SEZs are exempt from public hearings for any kind of environmental impact (Patel, 2012).

Figure 1. Location of fishing villages affected by industrial development



Source: Patel (2012)

Basumatary (2014) in his study quotes the ongoing concerns of activists and fish-workers in Mundra as follows:

> " *The fishing community has been constantly shifting from the eastern part of the Gandhidham coast to the western part due to the continuous expansion of the development projects towards the west. Initially the Kandla Port came up and the fishermen lost access to their coast. There was not much of a resistance and resentment as there was still many kilometeres of coastline available for fishing activities for the fishermen. So the fishermen shifted to the next site due west of their initial bander. Next another industry came in and they had to shift to another site to create their bander. Then they were pushed further west due to the establishment of private port and the SEZs. Today, they can only reach from their village through a route that goes through an 'environmental protected zone'. The anticipation is that the law makers are going to enact regulations to restrict people's access to these protected zones as well".*

As mentioned earlier, diverse impacts on the ecological and livelihood resources have been recorded. The power projects have encroached upon the grazing lands. The oceans are impacted by hot water discharge and pollution. The access to *banders* has been considerably restricted (Table 3).

Table 3. Livelihood Impacts of Industrial Projects in Mundra

Livelihoods	Impacts
Fisheries	Displacement from customary fishing sites. Decline in fish catch. Restricted access to banders. Destruction of mangroves.
Agriculture	Salination of ground water. Pollination getting impacted due to fly ash. Air pollution.
Cattle Rearing	Restricted access to grazing land.
Habitat	Destruction of coral reefs. Increase in soil erosion due to bunding. Pollution and changes in chemical composition of the ocean and marine life.

Source: Patel (2012); Basumatary (2014).

Kohli (2011) observes that 'for the people of Mundra coast, this massive and fast paced transition is now an everyday story. Theirs is a constant struggle to protect their commons, rights and the very socio ecological character of Mundra and surrounding coastlines from the massive land use changes being facilitated through approvals from the centres of power".

Case Analysis 3: Coastal Disaster Risk Reduction and Development Designs in Tamil Nadu

The Government of India and the World Bank signed a $236 million credit agreement to promote the resilience of coastal communities to a range of hazards by enhancing mitigation measures along the coast of Tamil Nadu and Puducherry. The project has significance in the context of the present paper as it aims "to reduce the vulnerability of coastal communities to a range of hydro-meteorological and geophysical hazards such as cyclones, storm surges, floods, tsunamis etc. through building resilient infrastructure, enhancing livelihood and coastal risk management capacity of stakeholders and improving the recipient's capacity of stakeholders and improving the recipient's capacity to respond promptly and effectively to an eligible crisis or emergency". (GoTN, 2013:5). The CDRRP has outlined five critical project components namely (i) vulnerability reduction, (ii) sustainable fisheries, (iii) capacity building, (iv) implementation support and (v) contingent emergency financing. The key features of these components are provided below.

The first component pertains to vulnerability reduction. The main thrust is 'to reduce the vulnerability of coastal communities through infrastructure such as permanent houses, evacuation shelter and routes and resilient electrical networks' (GoTN, 2013). This includes the construction of multipurpose evacuation shelters, installation of about 440 early warning

systems and laying out evacuation routes and underground electrical networks. The second component related to sustainable fisheries aims to upgrade infrastructure and promote an approach for co-management of fisheries and address sea safety aspects (*ibid*). These include the construction of two fish landing centres, reconstruction and modernisation of fishing harbours; provide permanent opening of two river bar mouths and establishing ice plants. The third component is desirous of capacity building in disaster risk management and coastal zone management. The focus of this component is to strengthen the capacity of government institutions, civil society, the school education system and coastal communities. It also envisages the strengthening of State Disaster Management Authority, Community-based Disaster Risk Management, curriculum development and developing an ICZM plan. The implementation support component refers to the provisions of incremental operating costs, operational cost of the project management and the implementation units. The contingent emergency financing component envisages scope to re-allocate project funds to support response and reconstruction activities in case of future disasters (*ibid*).

Nevertheless, when we critically analyse these components and their prescribed indicators, there are many contradictions inherent in these schema of neo-liberal, governmental rationalities. For instance, vulnerability reduction is reduced to mere structural mitigation measures, without realising that these structural mitigation measures can have serious long-term impact on the socio-ecological systems across varied temporal and geo-spatial locations. (The case study along the Kerala coast is an illustration for the same). Moreover, the socio-ecological vulnerability of coastal systems is not taken into consideration in any of these components. The notion of sustainability that is imposed upon is basically the market component aimed at boosting fish production and revenue and necessarily not sustainable development. The socio-ecological impact of these structures such as landing centres, fishing harbours, alterations in bar mouths etc. can seriously affect the coastal ecosystem and exacerbate or multiply the impact of hazards. This approach is thus entirely in contestation to the ecosystem-based approaches to sustainable livelihoods and disaster risk reduction. Debris storage, disposal problems, changes in water quality, marine impacts are already being reported (GoTN, 2013). Any form of environmental impact assessment is only measured in terms of scale but not in terms of variations to the coastal ecosystem, people's access to customary livelihood resources or in time-space implications. The cumulative impact of various fisheries infrastructure projects – past, present and future are therefore, completely neglected. These prevalent models of coastal zone management and disaster risk reduction are highly top-down in nature and are influenced by external expertise. Local knowledge and decentralised planning by primary stakeholders is completely missing in such endeavours. Such generic, neo-liberal forms of resource mainstreaming does not look into the uniqueness of socio-ecological systems of the coast or the rights of populations at risk.

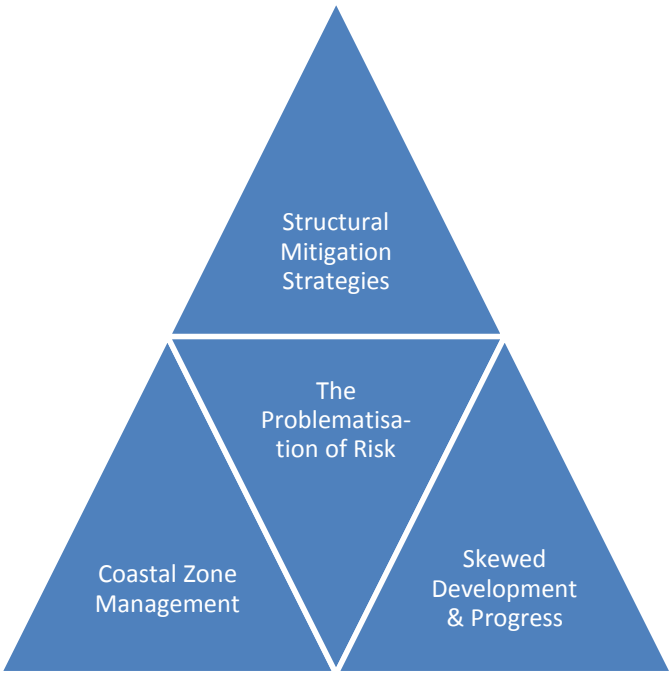
Concluding Observations

To conclude with, this paper asserts that disaster risk reduction measures, specifically structural mitigation strategies should take into account the ecosystem and livelihood related linkages into consideration. Nevertheless, coastal development, environment polices to manage the coast and coastal hazard mitigation strategies in India are stand-alone entities.

In practice, there is a clear disconnect between environment policies, disaster risk reduction and development strategies along the Indian coast. Yet another key observation of this paper is that risk reduction strategies in the context of coastal development and planning is placed amidst a strong positivist notion of hazards and a highly localised understanding of changes in ecological and livelihood resources. The heavy reliance on costly techno-centric solutions, their design and implementation is often a manifestation of dominant economic and political power structures, however are least sensitive to the vulnerability and livelihood contexts of marginalised population dependent on coastal resources for their livelihoods. In addition, these strategies have the potential to negatively impact upon the capacities and assets of these communities to deal with coastal hazards.

There is an urgent need to recognise the fact that risk reduction needs to be factored in all development projects planned along the coast. For, the coastal hazards can itself reduce the anticipated developmental outcomes and on the other hand these development processes if ill-conceived and unscientifically implemented can result in new forms of risk (Beck, 1992 ; Rego et al, 2010). The author presents a conceptual framework that explains the above-mentioned problems as a contested triangle (Figure 2).

Figure 2. The Contested Triangle

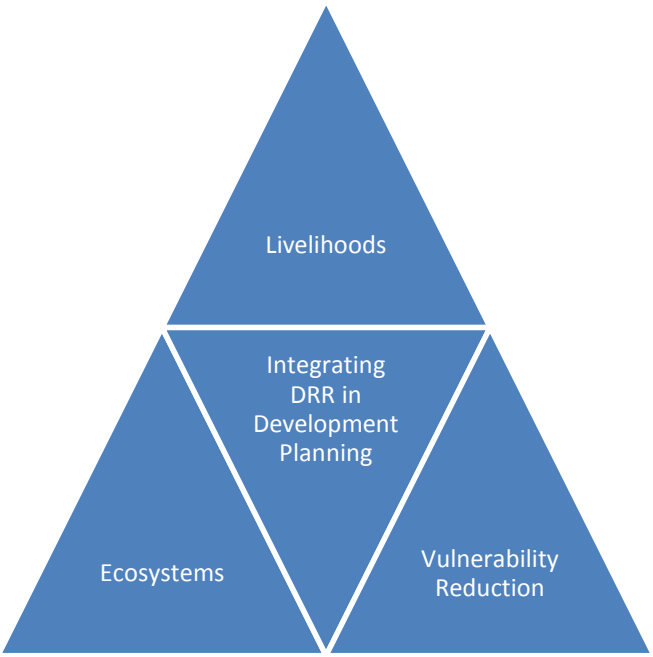


The above triangle problematises the notion of risk as an interface between skewed development policies and progress, structural mitigation strategies towards reducing disaster risk and isolated interventions of coastal zone management. Each actor involved in these three dimensions act in isolation without taking into account the other. This results in heightened vulnerability of populations and ecosystems to risk, insecure livelihoods and in the routinisation and regionalisation of risk. Development policies, coastal zone management and disaster risk reduction needs to take into account the diversity of coastal ecosystems and livelihoods, the culture and local knowledge systems of traditional fishing communities and their adaptation strategies while developing an integrated framework to deal with risk.

This paper argues for an inclusive disaster risk reduction framework, which through enhanced partnerships and cross-fertilization increases the resilience of both vulnerable coastal population and ecosystems in dealing with hazards. A significant step to develop and implement an inclusive disaster risk reduction framework is to mainstream disaster management concerns into developmental plans and projects. This implies that a separate ministry or department for disaster risk reduction is not a solution and that a series of discrete disaster risk reduction programs that are divorced from normal, well-funded development will never be effective. Thus, the conceptualisation of disaster risk reduction has to be integrated within the larger/specific development plans.

This paper believes that risk associated with hazards can become complex and problematic due to mal-adaptation and fragmented understanding of ecosystems, hazards and livelihood linkages. It advocates that formal adaptation initiatives can become meaningful, if the role and expertise of resource-dependent communities are recognised and are involved in designing and shaping adaptation measures. Integrating disaster risk reduction in development planning also requires the promotion of sensible coastal development and disaster preparedness along with enhanced capacities of social and ecological systems (Feagin et al, 2010). Ecosystem-based approaches are still not a priority in prominent disaster risk reduction approaches (Renaud et al,2013). Secondly, integration of both disaster risk reduction and ecosystem approaches has not yet become a priority in development planning. The scientific quantification of ecosystem services for disaster risk reduction still remains a challenge (*ibid*). In the context of above-discussion, the present paper proposes an alternative framework that could enable policy makers in dealing with coastal hazards (Figure 3).

Figure 3. The Balanced Triangle



The above triangle suggests that the focus should be towards improving livelihoods and quality of life that are in tune with environmental conservation and judicious natural

resource management, which can contribute to economic development that is sustainable in nature. This requires the nurturing of innovating local cooperative action and knowledge systems. To achieve this, one has to revisit the constructs of 'mitigation', 'adaptation' and 'development' in the context of existing and future hazards, coastal environment and socio-economic vulnerabilities.

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