सत्यमेव जयते
Government of India

Ministry of Environment, Forest and Climate Change

CLIMATE CHANGE AND THE VULNERABLE INDIAN COAST

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Publication Information

CLIMATE CHANGE AND THE VULNERABLE INDIAN COAST

Citation:
MOEFCC, (2018). *CLIMATE CHANGE AND THE VULNERABLE INDIAN COAST*
Edited by Ramesh. R, Bhatt J.R.
Ministry of Environment, Forest and Climate Change, New Delhi.

ISBN 978-93-5346-195-9

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Design and production:
Majix Design, 5-2B Nat West Vijay, Pallikaranai, Chennai 600100

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15 Climate Change Challenges on Indian marine fisheries sector

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ABSTRACT

Climate change can have a significant influence on terrestrial and aquatic biodiversity at all system levels – ecosystem, species and genetic. Marginalised sections of communities will further be pushed due to the impacts of climate change. The effect on the marine ecosystem will be multipronged affecting the environment, the resources and the resource users, affecting the sustainability. Primary strategies and policies will have to be sensitive to all the components separately, yet complimenting each other. This chapter is part of the studies undertaken for the Belmont Forum funded project titled `Global Learning and Understanding for Local Solution' (GULLS) to reduce the vulnerability of marine-dependent coastal communities in two marine fishing villages in Kerala, southwest India by attempting to test a climate resilient village adaptation and mitigation plan (CReVAMP) for vulnerable coastal communities with the understanding that overall vulnerability could be mitigated only by increasing the adaptive capacity of the population. Blue economy emerges as a commonly acceptable development paradigm which will effectively blend economic growth with sustainable development. Policies on adaptation need to consider multiple scales of climate change effects. Integrating adaptation and mitigation will increase the local legitimacy of the plan, as adaptation emphasizes on local needs.

1. Introduction

Climate change has been a topic of growing concern in terms of its reality and its acceptability as a reality. The ongoing debate around the world about climate change, actions to be taken and responsibility sharing dilemma between developed and developing nations are adding to the trouble. Climate change impacts can be seen on the environment and the most vulnerable communities, and if appropriate adaptation and mitigation measures are not considered, it will have - reaching negative outcomes at a huge cost.

Climate change is expected to have a significant influence on terrestrial and aquatic biodiversity at all system levels – ecosystem, species and genetic diversity. The changing climate will stimulate species-level changes in range and abundance, life cycle and behaviour, and, over time, genetic evolutionary responses. These changes will in turn be linked with changes in natural disturbance patterns and changes in ecosystem structure and function.

The most concerning factor regarding climate change is that the marginalised sections of the society are at the frontlines of facing the impacts of climate change, pushing them further to the edge. Climate change is going to strike at the root of these sections of the society already grappling with the constant problem of poverty and unemployment. Farmers and fishers who heavily depend on natural resources for their livelihood are going to find it difficult to survive this impending disaster if not given appropriate and effective support. Shifting rainfall patterns, recurring floods, stronger cyclones and droughts or soil erosion are exacerbating the challenge of poverty eradication and necessitate the allocation of scarce national resources for preventing loss of human life.

Scientists have been observing a change in the climate since the beginning of the 20th Century that cannot be attributed to any of the 'natural' influences of the past. Global warming has occurred faster than any other climate change recorded by humans and so is of great interest and importance to the human population. Various anthropogenic (human caused) factors responsible for climate change includes greenhouse gases, aerosols and changed land use patterns. It is high time that every country whether developing or developed, realises this threat and makes comprehensive adaptation and mitigation (A& M) plans for the common good of humanity.

Global warming as a result of Climate change has increased the vulnerability of social and biological systems to relatively sudden changes, which will last many years. So, climate change adaptation is necessary to offset the effects of global warming. Adaptation strategies are needed at all levels of administration to make them more effective. Successful adaptation not only depends on governments but also on the active and sustained engagement of stakeholders including national, regional, multilateral and international organisations.

Mitigation is an intervention to reduce emissions sources or enhance the sinks of greenhouse gases. Mitigation addresses the causes of climate change (accumulation of greenhouse gases in the atmosphere), whereas adaptation addresses the impacts of climate change.

Both approaches are needed. On the one hand, even with strong mitigation efforts, the climate would continue changing in the next decades and adaptation to these changes is necessary. On the other hand, adaptation will not be able to eliminate all negative impacts and mitigation is crucial to limit changes in the climate system.

Adaptation and mitigation differ in terms of spatial scales: even though climate change is an international issue, adaptation benefits are local and mitigation benefits are global. Mitigation is a priority in the energy, transportation, industry and waste management sectors whereas Adaptation is a priority in the water and health sectors and in coastal or low lying areas.

Climate change, more particularly harsher weather conditions, will have impact on the quality, productivity, output and viability of fish and aquaculture enterprises, thereby affecting fishing community. The small-scale fishers may be faced with greater

uncertainty as availability, access, stability and use of marine food and supplies would diminish and work opportunities would dwindle. Aquaculture development opportunities will increase in particular in tropical and sub-tropical regions. The climate change in warmer regions offers new opportunities as production in warmer regions will increase because of better growth rates, a longer growing season and the availability of new fish farming areas where it was once too cold.

Climate change will affect individuals, populations and communities through the individuals' physiological and behavioral responses to environmental changes (Boesch and Turner, 1984). Extremes in environmental factors, such as elevated water temperature, low dissolved oxygen or salinity, and pH, can have deleterious effects on fishes (Moyle and Cech, 2004). Suboptimal environmental conditions can decrease foraging, growth and fecundity, alters metamorphosis and affects endocrine homeostasis and migratory behaviour (Barton and Barton, 1987; Donaldson, 1990; Portner et al., 2001). These organismal changes directly influence population and community structure by their associated effects on performance, patterns of resource use, and survival (Ruiz et al., 1993; Wainwright, 1994). Climate affects the distribution and abundance of species in ecosystems around the world. In the face of rising temperatures, the ocean may experience variations in circulation, water temperature, ice cover, and sea level (McCarthy et al., 2001). Climate-driven fluctuations in regional temperature can further affect growth, maturity, spawning time, egg viability, food availability, mortality, and spatial distribution of marine organisms (Ottersen et al., 2001; Perry et al., 2005; Nye et al., 2009). Also affected by climate change are the size and timing of plankton blooms, a major driver of marine ecosystem function with a direct impact on recruitment success and population sizes (Walther et al., 2002; Fischlin et al., 2007).

2. Impact of climate change on Marine Ecosystem and its components

The marine ecosystem is affected in many ways and the major components that get affected due to climate change are illustrated in Figure 1. The three major components that have to bear the brunt of climate change include the environment, the resources and the resource users. Each component is equally important for maintaining the balance and sustainability of our existing marine ecosystem. Major strategies and policies need to be developed considering all the components separately, yet supporting each other.

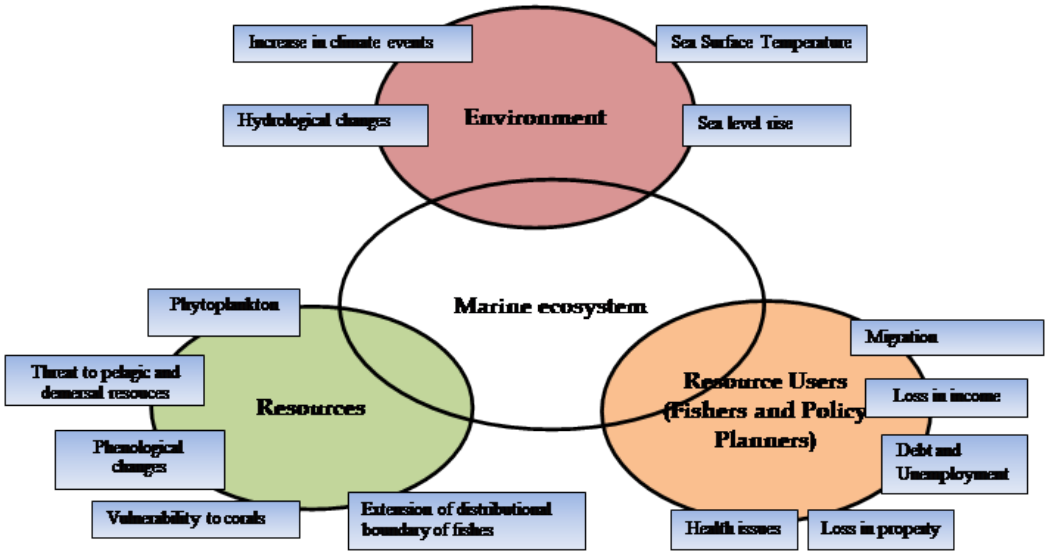

Figure 1: Impact of climate change on Marine Ecosystem and its components

3. Impactof climate change on Environment

Global warming is expected to have the potential to increase the atmospheric temperature by 1.3°C by 2040 compared to 1850-1900. A 1.5°C average rise may put 20-30% of species at risk of extinction. The atmospheric concentration of CO_2 reached 400 ppm for the first time in human history, up from pre-industrial levels of 280 ppm.Annual mean Arctic sea-ice extent decreased from 1979 to 2012, approximately at a rate of 3.5-4.1 % / decade. Sea level is predicted to rise between 0.24 - 0.3 meters by 2065 compared to mean levels for 1986-2005. Increased sea surface temperature, ocean acidification, coral bleaching, tree-lines shifting pole ward and upward are other major consequences of climate change.

4. Impactof climate change on Resources

Studies on the impact of climate change on fisheries (fish species, stock distribution etc.) have been carried out mainly by CMFRI, Kochi. Investigations carried out by CMFRI show that different Indian marine species will respond to climate change as follows: (i) Changes in species composition of phytoplankton may occur at higher temperature; (ii) Small pelagic may extend their boundaries; (iii) Some species may be found in deeper waters as well; and (iv) Phenological changes may occur.

a. *Indian mackerel is getting deeper:* Besides exploring northern waters, the Indian mackerel *Rastrelliger kanagurta* has been descending deeper as well during the last two decades (CMFRI, 2008). The fish normally occupies surface and subsurface waters. During 1985-89, only 2 percent of the mackerel catch was from bottom trawlers, the remainder was caught by pelagic gear such as drift gillnet. During 2003-2007, however, an estimated 15 percent of the mackerel has been caught by bottom trawlers along the Indian coast. It appears that with the warming of sub-surface waters, the mackerel has been extending deeper and downward as well.

b. *Small pelagics extend their boundaries:* The oil sardine *Sardinella longiceps* and the Indian mackerel *R. kanagurta* accounted for 21 percent of the marine fish catch in 2006. These small pelagics, especially the oil sardine, have been known for restricted distribution – between latitude 8°N and14°N and longitude 75° E and 77° E (Malabar upwelling zone along the southwest coast of India) where the annual average SST ranges from 27 to29°C. Until 1985, almost the entire catch was from the Malabar upwellingzone, there was little or no catch from latitudes north of 14°N. During the last two decades, however, catches from latitude 14°N - 20°N are increasing. In 2006, catches in this area accounted for about 15 percent of the all-Indian oilsardine catch. The higher the SST, better the oil sardine catch. The surface waters of the Indian seas are warming by 0.04°C per decade. Since the waters in latitudes north of 14°N are warming, the oil sardine and Indian mackerel are moving to northern latitudes. It is seen that catches from the Malabar upwelling zone have not gone down. It can be inferred that the sardines are extending northward, not shifting northward. The Indian mackerel is also found to be extending northward in a similar way. According to CMFRI, the catch of oil sardines along the coast of Tamil Nadu has gone up dramatically, with a record landing of 185877 tonnes in 2006. The presence of the species in new areas is a bonus for coastal fishing communities. Assessing their socio-economic needs will greatly help in developing coping strategies for adaptation to climate impacts. WWF is currently documenting community perceptions and experiences in relation to the oil sardine fishery of the eastern coasts.

c. *Spawning:* Fishes have strong temperature preferences so far as spawning goes. The timing of spawning, an annually occurring event, is an important indicator of climate change. Shifts in the spawning season of fish are now evident in the Indian seas. The thread fin breams *Nemipterus japonicas* and *N. mesoprion*are

distributed along the entire Indian coast at depths ranging from 10 to 100 m. They are short-lived (about 3 years), fast growing, highly fecund and medium-sized fishes (35 cm). Data on the number of female spawners collected every month off Chennai from 1981 to 2004 indicated wide monthly fluctuations. However, a shift in the spawning season from warmer to relatively cooler months (from April-September to October-March) was discernible (Vivekanandan and Rajagopalan, 2009).These changes may have an impact on the nature and value of fisheries (Perry et al., 2005). If small sized, low value fish species with rapid turnover of generations are able to cope up with changing climate, they may replace large-sized high value species, which are already declining due to fishing and other non-climatic factors (Vivekanandan et al., 2005). Such distributional changes might lead to novel mixes of organisms in a region, leaving species to adjust to new prey, predators, parasites, diseases and competitors (Kennedy et al., 2002), and result in considerable changes in ecosystem structure and function.

d. *Vulnerability of corals:* In the Indian seas, coral reefs are found in the Gulf of Mannar, Gulf of Kachchh, Palk Bay, Andaman Sea and Lakshadweep Sea. Indian coral reefs have experienced 29 widespread bleaching events since 1989 and intense bleaching occurred in 1998 and 2002 when the SST was higher than the usual summer maxima. By using the relationship between past temperatures and bleaching events and the predicted SST for another 100 years, Vivekanandan et al. (2009a) projected the vulnerability of corals in the Indian Seas. They believe that the coral cover of reefs may soon start declining. The number of decadal low bleaching events will remain between 0 and 3 during 2000-2089, but the number of decadal catastrophic events will increase from 0 during 2000-2009 to 8 during 2080-2089. Given the implication that reefs will not be able to sustain catastrophic events more than three times a decade, reef building corals are likely to disappear as dominant organisms on coral reefs between 2020 and 2040. Reefs are likely to become remnant between 2030 and 2040 in the Lakshadweep Sea and between 2050 and 2060 in other regions in the Indian seas. These projections take into consideration only the warming of seawater. Other factors such as increasing acidity of seawater are not considered. If acidification continues in future as it does now, all coral reefs would be dead within 50 years. Given their central importance in the marine ecosystem, the loss of coral reefs is likely to have several ramifications.

Fresh research studies have found out new areas of concern for fisheries due to increased global warming. Scientists from Indian National Centre for Ocean Information Services (INCOIS), a Ministry of Earth Sciences body and US National Oceanic and Atmospheric Administration (NOAA) have found that global warming is driving proliferation of Noctiluca algae (commonly known as sea tinkle), a harmful algae in Arabian Sea responsible for glowing of Mumbai's beaches in dark.

Noctiluca algae are parasites and compete with fish for food and choke their supply. It devours one of the most important planktonic organisms at base of fish-food chain, namely diatoms. It also excretes large amounts of ammonia, which causes massive fish mortality.

Warming of oceans due to global warming is increasing temperature difference among layers of sea water. This temperature differences has slowed the upward transport of nutrients like silicate from the ocean bottom, lowering its concentration at surface. Diatoms growing in surface water which need both sunlight and silicate to build their glass skeletons,fail to thrive when silicate is in short supply. On the other hand, Noctiluca algae remain unaffected by these changes and prey on remaining diatoms. Thus, the study shows that intensifying global warming conditions will disrupt fish-food chain and cause the decline of fisheries in the region.

Such newly emerging findings are adding to the concern and exposing the multifaceted effects of climate change which are yet to be ascertained and taken into account..

5. Impact of climate change on resource users

Climate change poses a significant threat to resource users, in particular, the fisher communities who are emotionally attached to their living environment as their livelihood is heavily dependent on sea.The impact of climate change in marineresource users includes, displacement of family members, food security issues, migration of fisher folk, fall in income level, seasonal employment, change inemployment pattern, increased fishing cost, reduction of fishing days etc.

a. *Demography and Social standards*: Displacement of family members increased over the years, the young generation has a tendency to move out of fishing. Food security issues increased rapidly in recent years. Disguised unemployment is rampant in all sectors since earnings from marine fisheries are not proportionate to the increase in fishers. This has instigated labour migration induced by the earning potential in the distant waters coupled with limited resources in their vicinity.

b. *Infrastructure sensitivity*: Increased frequency and severity of storms orweather, and sea conditions are unsuitable to fishing as well as damaging to communities on shore through flooding, erosion, and storm damage. Proximity to hazard areas makes the fisher households highly prone to disasters resulting in substantial property losses.

c. *Income Effect*: The income levels of fishers decreased substantially over the years. The employment pattern has been mostly seasonal, and alternate avocation options are minimal, there is also economic loss due to loss in number of fishing days. Changed fishing ground caused increased cost of fishing andfish storage. The fuel cost, the cost of fishing gear and boat are increasing significantly over the years.

The study conducted in the most climate change vulnerable marine hotspots of Kerala (Elamkunnapuzha and Poonthura) by Shyam et al. 2014 explains the problems and prospects of the inhabitants in the sector and the importance of Alternative Livelihood Options (ALOs) for climate change adaptation. Based on the assessment, it was understood that climate change has impacted coastal communities, mainly fisher communities. Around 70 per cent of them needed alternative livelihood option supports. The preferred alternative livelihood means include daily wages jobs, service industry, small scale industries etc. Coastal communities (75.95 %) are willing to participate in adaptation and mitigation programmes against climate change and majority (61 %) of the respondents would like to take part in individual climate change adaptation activities followed by household and social roles.

To tackle this problem of climate change it is imperative that the coastal communities be aware of its repercussions and are willing to participate at every stage of the planning process. To be effective, every climate change adaptation and mitigation strategy should be specific according to the needs of the community members. Climate change is an issue affecting large sections of the society and needs integration of plans at different levels viz., international, national, state, district, panchayat etc. Co-management of adaptation and mitigation strategies involving community members is going to have long term and sustainable effects in compacting climate change. Science and civil society must share their expertise, knowledge and capacity of action to be even stronger and more efficient to protect the ocean.

Coasts are experiencing the adverse consequences of hazards related to climate and sea level, extreme events, such as storms, which impose substantial costs on coastal societies (Shyam and Manjusha, 2015). The coastal regions around the globe are more prone to the impacts of climate change than the mainland. Fishing being one of the primary occupations of the coast, the fishermen community is the most vulnerable group to be affected by climate change. Adaptation for the coasts of developing countries will be more challenging than for coasts of

developed countries, due to constraints on adaptive capacity. Climate change has the potential to affect all natural systems thereby becoming a threat to human development and survival socially, politically and economically. Beyond basic findings of levels of concern, awareness and belief in human impact on the climate, some recent studies have attempted to delve deeper into public attitudes about climate change. Furthermore, awareness of climate change is a prerequisite for adaption and mitigation plans and programs in any community. In addition, it is quite relevant to take advantage of the key informants within the community to disseminate the need for long term and short term adaptation and mitigation options to combat the climate change impacts and thereby making the community more resilient to climate change issues.

A study was carried out to assess the level of awareness of vulnerable fishing communities of Ernakulam district of Kerala, about climate change and to identify the level of adaptation and mitigation strategies available and adopted by them (Shyam et al., 2015). Njarackal (highly vulnerable village) and Ochanthuruth (moderately vulnerable village) were selected for the study. Across the villages, it was found that 98% of the respondents have heard about climate change at a time or the other however it was found that awareness about climate change was less than 40 percent. There is a discrepancy between hearing and awareness about climate change; hearing means only superficial knowledge about climate change. The significant sources of information were found to be different media, friends, and relatives. But awareness involves in depth understanding about climate change which indicate that the people know the causes, impacts, consequences, the societal need and commitment towards its preparedness, adaptation measures *etc*. The perception of the visible features consequent to climate change is the extent of their agreement to the variables such as sea level rise, temperature increase, change in wind pattern, extreme weather events, sea water intrusion, water scarcity, property loss, erratic weather, diseases etc. that affect them.

Knowledge on climate change among the respondents of both these villages was very shallow and pertained to short term happenings. Awareness on climate change is a prerequisite to initiate steps in combating negative impacts of climate change. Though changing climatic condition is a global concern, the possible mitigation options for improving adaptive capacity needs to be local. An integrated approach comprises of actions for addressing long term and short term concerns of the community, through grass root level actions which would have to be initiated in materialising local solutions to compact the cumulative impact of climate change.

GULLS (Global understanding and learning for local solutions), a four-year project that began in 2014 looked at the low-level of awareness on climate change among fishers in Kerala owing to the fact that such change issues were entangled with other developmental issues; thereby the community could not decipher anything other than loss in fishing days and extreme weather events that could be related to climate change.

A strategy was conceptualised for planning and implementing village level adaption and mitigation plan through sensitizing and improving the resilience of community towards climate change and initiating a multi stakeholders platform for developing a climate knowledge and information systems; CReVAMP' – "Climate Resilient Village Adaptation and Mitigation Plan". This is facilitated using a multi stakeholder governance model by bringing different stakeholders together to participate in the dialogue, decision making, and knowledge sharing and there by instigating knowledge generation process within the community during the process. This then is directed to create a village information system within the community, enable green fishing practices and prepare adaptation and mitigation plan for the community. This would, in turn, help in community empowerment, thus enabling in building resilient community /Climate Change Informed Fisher Community (CCIF). Through this process, they are expected to influence the society and government in decision making and actions related to climate change mitigation and would eventually be able to influence the policy- making process (Figure 2)

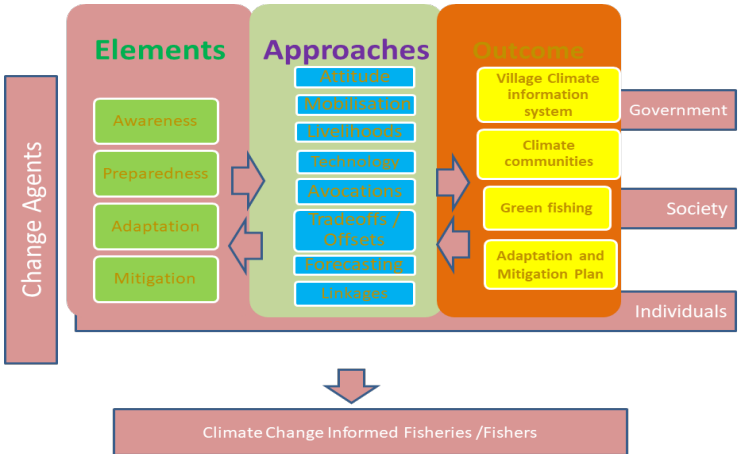

Figure 2: CReVAMP Framework

Two marine fishing villages in Kerala have been chosen to test a climate resilient village adaptation and mitigation plan (CReVAMP) for vulnerable coastal communities in tropical countries. Twenty four climate change hotspots, regions warming faster than the global average, have been recognised around the world. Each of these has a unique suite of species which inhabit them, and all are important to the countries surrounding them in supporting fisheries, tourism and in hosting important ecosystems.The hotspot area of south -west India comprises of four coastal districts (South Zone: Thiruvananthapuram & Kollam and Central zone: Ernakulam and Alapuzha), and the rationale behind the selection of this particular location is i) It falls within the upwelling ecosystem of the south-west coast of India, ii) this region has rich diversity and supports substantial marine and estuarine fisheries iii) identified as major spawning gyre of many pelagic species based on fish and larval surveys iv) has extensive system of backwaters.

The study titled GULLS covered spatial scales across southern Africa, western and southern Australia, Mozambique Channel and Brazil in addition to South India. The climate change vulnerability of over 1,000 fishermen households in two major fishing villages of Kerala (Elamkunnapuzha in Ernakulam and Poonthura in Thiruvananthapuram) was assessed. Exposure, sensitivity and adaptive capacity were the pertinent factors that determine the vulnerability. The method used was a structured household questionnaire. The coastal population was categorized as low, moderate, high and very high on their vulnerability scores and a geospatial analysis was attempted.

A composite vulnerability index approach was used in this study to evaluate relative exposure, sensitivity, and adaptive capacity. The mean values of the three sub-indices of Exposure (E), Sensitivity (S), and Adaptive Capacity (AC) were combined to develop a composite vulnerability index by using the following additive (averaging) equation.

Vulnerability (V) = Exposure (E) + Sensitivity (S) - Adaptive Capacity (AC)

The salient finding of the study was that the overall vulnerability could be reduced only by increasing the adaptive capacity of the population.It is against this backdrop that 'Blue economy' has emerged as a commonly acceptable development paradigm which has effectively blended economic growth with sustainable development.

Blue economy refers to marine-based sustainable economic development which leads to improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Integrating climate change and blue economy can open up fresh opportunities and solutions which will help these vulnerable coastal communities to become resilient to climate change impacts (Figure 3).

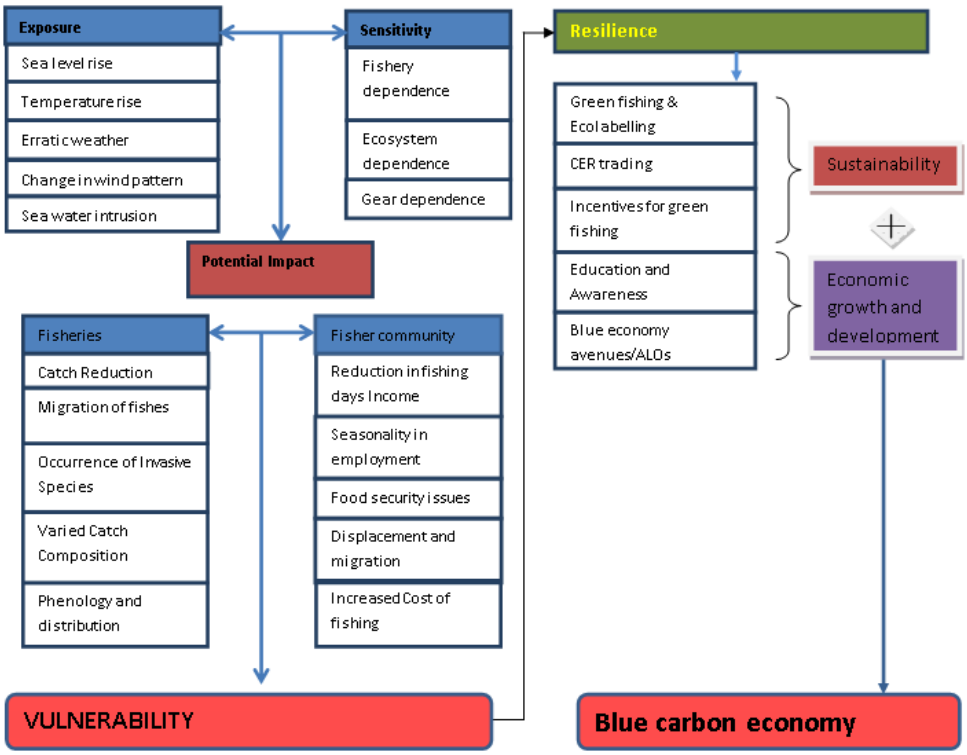

Figure 3: Integrating climate change and Blue Economy in Marine fisheries

6. Blue Economy Avenues

Blue economy is going to be the source of many alternative and climate change resilient avenues that is going to lift the environment, resources and the resource users out of the unsustainable ecosystem that exists today. Blue economy guarantees a green perspective to the maritime economy which is presently seen as a means of free resource extraction and waste dumping. It seeks to take into cognisance the cost of all negative externalities including environmental degradation and ecological imbalance. In short, it postulates a complementary apparatus to the existing brown model of ocean economy (WWF, 2015).

Figure 4: Blue Economy Avenues

The Way Forward

Climate change as a phenomenon should not get restricted as subjects of discussions for scientists and researchers and a topic of debate for the political and environmental bodies. It should be considered as a serious issue having enormous repercussions, many of which are yet to be found out. Concerning mitigation, the distinction enshrined in the Convention between Annex I (Developed) and non Annex I (developing) Parties must be maintained in accordance with the principles of Equity, CBDR (Common but Differentiated Responsibilities) and other provisions of the UN Conventions. The 'developing versus developed country' schism needs to be diluted at the earliest and Developed Countries should avoid watering down the CBDR principle envisaged in earlier agreements.

Politics and power struggle to control resources need to be set aside so that the most vulnerable sections in the society, who are get affected more by climate change impacts, are assured that they will be safe to pursue their lives and livelihoods. Mechanisms to anticipate and deal with climate change should be jointly developed by all the countries in the world and incorporated well in advance. Measures to prevent elite networks to capture and misuse land, water and other resources should be identified. Equity issues are primary to address the vulnerabilities and costs while framing policies and strategies to tackle climate change. Policies on adaptation should also consider the multiple scales of effects. Integrating adaptation and mitigation will increase the local legitimacy of the plan, as adaptation puts emphasis on local needs.Climate change is no unidirectional issue; it has effects on both the resources and resource users. Thus the adaptation to climate change impacts should ensure that the multifarious impacts it brings along can be tackled.

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