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CLIMATE CHANGE IMPACTS : REFLECTIONS AND UPSHOTS ON INDIAN MARINE ECOSYSTEM

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Climate change

Intergovernmental Panel on Climate Change (IPCC) defines Climate change as "A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use". In its Fourth Assessment Report, IPCC projects that, without further action to reduce greenhouse gas emissions, the global average surface temperature is likely to rise by a further 1.8 - 4.0°C this century, and by up to 6.4°C in the worst case scenario. Even the lower end of this range would take the temperature increase since pre-industrial times above 2°C – the threshold beyond which irreversible and possibly catastrophic changes become far more likely. The present paper elucidates the impact of climate change on marine ecosystems, fish and fisheries and suggests various vulnerability assessment methods and adaptation options to cope up with climate change. The paper also deal with the research efforts and linkages attempted in developing a climate informed fisher society.

Climate change and marine ecosystem

The marine ecosystem is constituted by an intricate set of relationships among environment, resources and resource users (Fig.1). Changing climate affects ecosystem in a variety of ways. For instance, warming may force species to migrate to higher latitudes or higher elevations where temperatures are more conducive to their survival. Similarly, as sea level rises, saltwater intrusion into a freshwater system

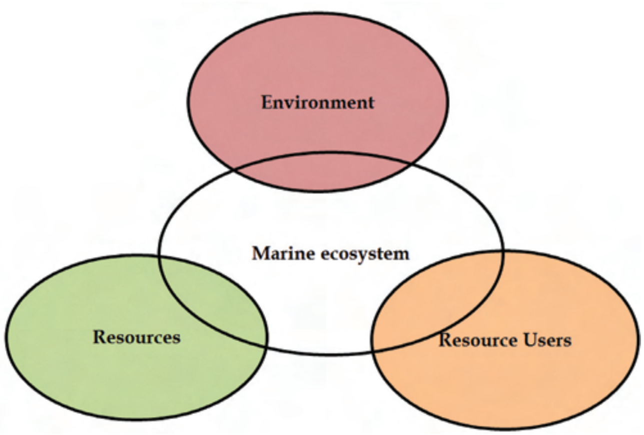


Fig. 1. Marine Ecosystem and its components

may force some key species to relocate or die, thus removing predators or prey that are critical in the existing food chain. Climate change not only affects ecosystems and resources directly, it also interacts with the general well being of resource users or community as a whole.

I. Impact of climate change on environment

Marine ecosystems are not in a steady state, but are affected by the environment, which varies on many spatial and temporal scales. Changes in temperature are related to alterations in oceanic circulation patterns that are affected by changes in the direction and speed of the winds that drive ocean currents and mix surface waters with deeper nutrient rich waters (Kennedy *et al*., 2002). These processes in turn affect the distribution and abundance of plankton, which are food for small fish. Understanding the importance and the implication of the climate changes on coastal areas may be one of the major issues for this and next centuries.

Climate changes may, indeed, impact the nearshore marine environment, as coastal areas are very sensitive to the strength and the variability of the meteorological forcings. An increase of a few degrees in atmospheric temperature will not only raise the temperature of the oceans, but also cause major hydrologic changes affecting the physical and chemical properties of water. These will lead to fish, invertebrate, and plant species changes in marine and estuarine communities (McGinn, 2002). Fishes have evolved physiologically to live within a specific range of environmental variation, and existence outside of that range can be stressful or fatal (Barton *et al.,* 2002). These ranges can coincide for fishes that evolved in similar habitats (Attrill, 2002). Estuarine and coastal regions are extremely productive because they receive inputs from several primary production sources and detrital food webs. Yet, these systems present the biota with a harsh environment, forcing organisms to evolve physiological or behavioral adaptations to cope with wide ranging physical and chemical variables (Horn *et al*., 1999). Temperature, along with other variables, causes active movement of mobile species to areas encompassing the preferred range of environmental variables, influencing migration patterns (Rose and Leggett, 1988; Murawski, 1993; Soto, 2002). The predicted increase in major climatic events, such as ENSO (Timmermann *et al*., 1999; IPCC, 2001), may have drastic effects on fish stocks, especially when combined with other factors, such as overfishing (Pauly and Christensen, 1995). It has been suggested that reduced survival, reduced growth rate, and diversions of traditional migratory routes can all be caused by ENSO events, exacerbating the effects of intensive harvesting (Miller and Fluharty, 1992). The El Nino phenomenon generates substantial changes in oceanographic and meteorological conditions in the Pacific Ocean, with manifestations impacting the Peruvian coast (Zuta *et al.*, 1976); this has mainly affected pelagic resources, producing alterations in their biological processes, behaviour, and gradual decrease in their population levels (Valdivia, 1976).

(i) **Sea level rise in the Indian seas**

The IPCC (2007) has projected that the global annual seawater temperature and sea level would rise by 0.8 to 2.5° C and 8 to 25 cm, respectively by 2050. At present, 23% of the shoreline along the Indian mainland is affected by sea erosion (Sanil Kumar *et al.*, 2006). The large inflow of freshwater into the seas around India due to rainfall over the ocean and runoff from rivers, forces large changes in sea level especially along the coasts of Bay of Bengal. During June-October, the inflow of freshwater from the Ganges and Brahmaputra into the northern Bay Bengal is about $7.2 \times 10^{11} m^3$, the fourth largest discharge in the world (Shankar, 2000). Increase in sea level, in addition to causing threats to human lives, will pose problems on freshwater availability due to intrusion of seawater and salinisation of groundwater. This would also result in loss of agricultural land. A rise in sea level is likely to have significant impact on the agriculture performance in India. A one metre sea level rise is projected to displace approximately 7.1 million people in India and about 5,764 km^2 of land area will be lost, along with 4,200 km of coastal roads (Ministry of Environment and Forests, 2004). Approximately 30% of India's coastal zones will be subjected to inundation risk with sea level rise and intensified storm surges (Dasgupta *et al.*, 2009).

(ii) **Sea Surface Temperature**

Prasanna Kumar *et al.,* (2009) examined the signature of global warming using various datasets for the Arabian Sea region and found that the disruption in the natural decadal cycle of SST after 1995 was a manifestation of regional climate-shift. They propose that upwelling driven cooling was maintained till 1995 despite oceanic thermal inertia and increasing CO_2 concentrations but this system broke down after 1995 though it is not known yet how long this process will continue. Vivekanandan *et al.,* (2009a) found warming of the sea surface along the entire Indian coast. The SST increased by 0.2°C along the northwest, southwest and northeast coasts and by 0.3°C along the southeast coast during the 45-year period from 1960 to 2005. The team has predicted that the annual average SST in the Indian seas would increase by 2.0°C to 3.5°C by 2099. Upwelling in the waters of the southwest coast of India is restricted to 5 to 15°N, and the variability in physical parameters is manifested in the chlorophyll intensity [Smitha *et al.,* 2008]. Remotely sensed sea surface temperature (SST) and ocean-colour images reveal eddies and fronts. These features frequently coincide with areas where fish species aggregate as a result of enhanced primary productivity and phytoplankton biomass, which in turn is linked with increased nutrient supply. Since, higher plant biomass is associated with zooplankton abundance, this could provide supplementary information on fish stock distribution from ocean-colour pigment fields.

II. Impact of climate change on resources

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 behavior (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).

Studies on the impact of climate change on fisheries (fish species, stock distribution *etc*.) have been carried out mainly by the CMFRI, Kochi. Investigations carried out by the 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 pelagics 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 *R. 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 *Rastrelliger 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 and 14°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 to 29°C. Until 1985, almost the entire catch was from the Malabar upwelling zone, 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-India oil sardine catch. The higher the SST, the better the oil sardine catch (Vivekanandan *et al.,* 2009a). 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. Inference: 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 185 877 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: threadfin breams like it cool:* Fish 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 threadfin breams *Nemipterus japonicus* and *N. mesoprion* are distributed along the entire Indian coast at depths ranging from 10 to 100 m. They are short-lived (longevity: about 3 years), fast growing, highly fecund and medium-sized fishes (maximum length: 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.,* (2009b) 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.

III. Impact of climate change on resource users

Climate change poses a great 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 marine resource users includes, displacement of family members, food security issues, Migration of fisherfolk, fall in income level, seasonal employment, change in employment 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 or weather, and sea conditions are, unsuitable to fishing as well as damaging to communities on shore through flooding, erosion, and storm damage. There is proximity to hazard areas the fisher household are highly prone to disaster dwellings and the property loss increased over the years.

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 and fish storage. The fuel cost, the cost of fishing gear and boat are increasing significantly over the years.

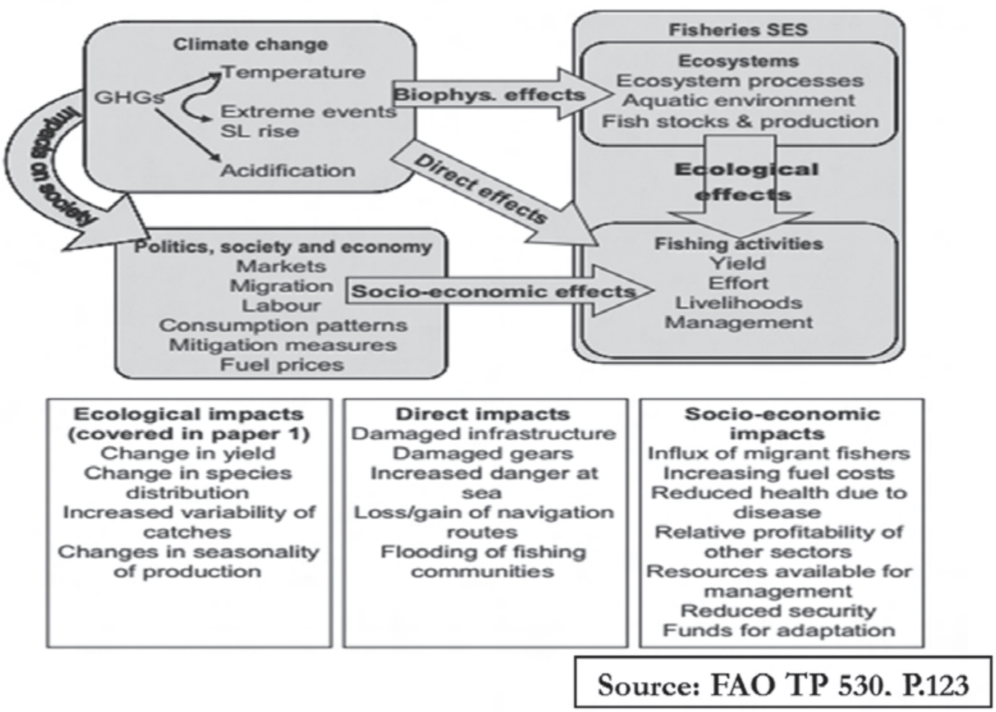


Fig. 2. Ecological, direct and socioeconomic impacts of climate change on fisheries

Climate Change and Coastal Communities – Need for awareness

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 globe are more prone to the impacts of climate change than the inlands, fishing being one of the primary occupations of the coast, the fishermen community is the most vulnerable group to be affected by the 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 about 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 on climate change is a prerequisite to kick start any adaption and mitigation plans and programs in any community. In addition, it is quiet 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.

Community perception on climate change

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. This was done by carrying out Vulnerability assessments- by employing vulnerability indices and preparing awareness schedules. Across the villages it was found that 98% of the respondents have heard about climate change at a time or the other but however it was found that awareness about climate change was less than 40 percent. There is discrepancy between hearing and awareness about climate change stems from the fact that hearing means it is only superficial knowledge about climate change. The major sources of information about hearing climate change could be different media, friends, relatives *etc*. but awareness involve an in depth understanding about climate change which indicate that the people know the causes , impacts, consequences, the society 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*. affected them.

More than 72 percent of the respondents strongly believed that climate change is due to the aftermath of industrialization which can be attributed to urbanization, habitat destruction, pollution and transportation, which they held as equally important sources of causes of climate change.

Respondents' perception on the major impact of climate change on resources including catch reduction, increased efforts in fishing, migration of fishes, varied catch composition, shift in spawning seasons, temporal shift in the species availability, loss in craft and gear, occurrence of invasive species, alterations in fishing seasons, depletion of farm and inventories, non-availability of regular species *etc*. In the context of the study, resources

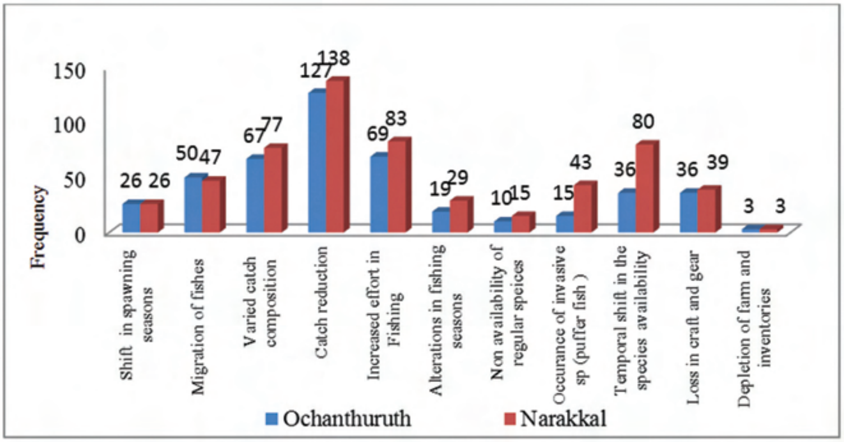


Fig. 3. Perception of climate change impact on resources

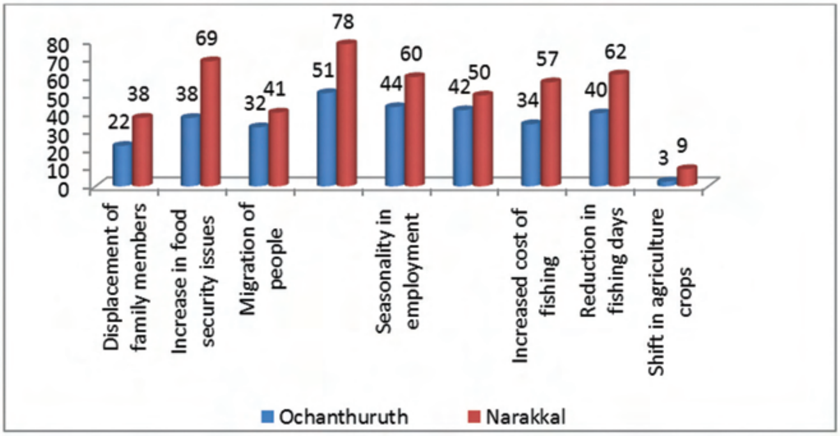


Fig. 4. Perception of climate change on resource users

indicate the fisheries sector and allied activities and the inventories involved. Climate change in every fisherman has a feeling that the fish catch has abridged. Fisher households are dependent on coastal and marine goods and services to a great extent, which serve as an important indicator as to how sensitive they could be in relation to climate events. There is a close association between climate change issues affecting the fishery resources and resource users. Respondents' perception on major impacts of climate change on resource users include displacement of family members, increase in food security issues, migration of people, substantial reduction in income, seasonality in employment, shift in employment pattern, increased cost of fishing, reduction in fishing days, shift in agriculture crops.

The 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 materializing local solutions to compact the cumulative impact of climate change.

Vulnerability assessment, Adaptations and Mitigations

Shyam *et al.,* 2014 constructed the vulnerability indices using Parameter, Attribute, Resilient indicator and Score (PARS) methodology, a conceptual framework developed for assessing the climate change vulnerability of coastal livelihoods under the initiative "National Innovations in Climate Resilient Agriculture" (NICRA). Under this initiative, the vulnerability of 318 fisher households in Alappuzha District of Kerala were assessed using PARS methodology (Shyam *et al.,* 2014). The methodology provides prioritisation and ranking of the different impacts as perceived by the fishers on environment, fishery and socio-economic parameters. The vulnerability indices were worked out for the fisher households. The fisher's perception revealed that fishery was most impacted followed by economic and environmental impacts. Social impact was the least as opined by fishers. The study indicates that long term effects of climate change aren't realised/perceived/impacted much among the fisher households. The fishers were more prone to loss in fishing days due to erratic monsoon.

The methodology was employed across the Theme III of IDLAM (Integrate District level Adaptation and Mitigation)and was adopted across the coastal villages of the country. The results suggest a bottom up approach with the proactive participation of the the primary stakeholders awareness by involving them in disaster preparedness, management and mitigation planning as well as implementation process.

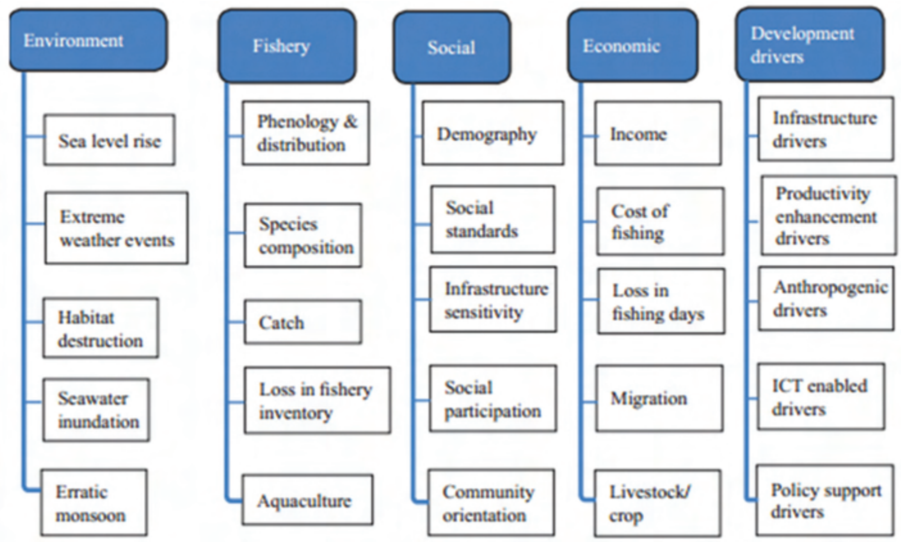


Fig. 5. Parameter and attributes used in PARS methodology frame work (Shyam *et al.*, 2014)

In general the fisher folk of Kerala are emotionally involved in their livelihood activities pertinent to their homestead habitat and are sensitive to the changes in their surroundings. Due to the lack of awareness about the big picture – The climate change, the fisherfolk are naïve in context to the source of the problems including temperature rise, extreme weather events, reduction in fish catch over years, change in fish composition over years and sea level rise. The process of providing right and comprehensive knowledge on climate change is the need of the hour; this can be achieved through a bottom up approach involving the primary stakeholders along with the community which will eventually position them to adequate climate change adaptation and mitigation by augmenting their traditional knowledge (Shyam *et al.*, 2014).

Climate change research - A GULLS initiative

The CMFRI research project on "Global understanding and learning for local solutions: Reducing vulnerability of marine-dependent coastal communities" (GULLS) under the theme on Coastal Vulnerability was sanctioned under an MoU of Belmont Forum and G8 Research Councils International Opportunities Fund. Focus areas of GULLS project include Southern Africa, Southern Australia, Western Australia, Mozambique channel, Southern India and Brazil. The GULLS project addressed the Belmont Challenge priorities in the area of coastal vulnerability – specifically the challenges that arise in food security and sustaining coastal livelihoods as a result of global warming and increasing human coastal populations. The project is contributing to improving community adaptation efforts by characterizing, assessing and predicting the future of coastal-marine food resources and identification of suitable adaptation options. The rationale for selection of the focus area included early observation of the impacts, strong incentives to initiate adaptive strategies, developing models for early prediction and validation, developing adaptation options and testing for challenges to be met efficiently and effectively.

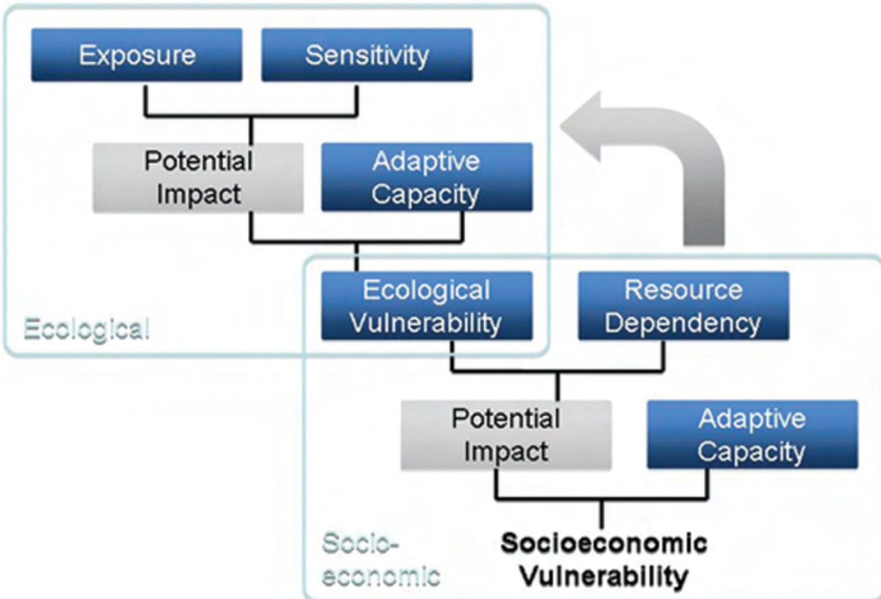


Fig. 6. Vulnerability model

Identification of climate change hot spots

Since hot spots in climate change parlance has not been identified yet in Indian context, it is high time to define and identify climate change hot spots in India to initiate comprehensive planning for adaptation and conservation measures. In this context Climate change Hot spots –can be defined as the "live *labs'* where the manifestation of the climate change impacts are observed "first". The identification of the climate change hot spots would help policy makers in priority setting and in planning adaptation and conservation measures.

The coastal vulnerability assessment in GULLS project underlines, a demarcation between fishery hotspots (based on fish abundance, phenology, distribution, range shifts, recruitment success *etc.*) and social hotspots (determining vulnerability, displacement, marginalization of traditional community) would be a novel idea to have representation of diverse factors in the project. Consistent with the objectives of GULLS, the activities will be aiming at assessing the current status of the fishery resources and ecosystem services and would attempt at predicting the future impacts of climate change on these resources and services apart from identification of key vulnerable marine species to climate change and assessing the community vulnerability.

The review done in addition to the discussions with the Belmont team resulted in boiling down the hotpsot region to (South West and South East Region of India).The South East India encompassing Ramanathapuram and Tuticorin districts of Tamil Nadu could be one of the Hotspot and the other be South West India(coastal districts of Kerala including Ernakulum, Alappuzha, Kollam and Trivandrum) with fisheries abundance and distribution shifts.

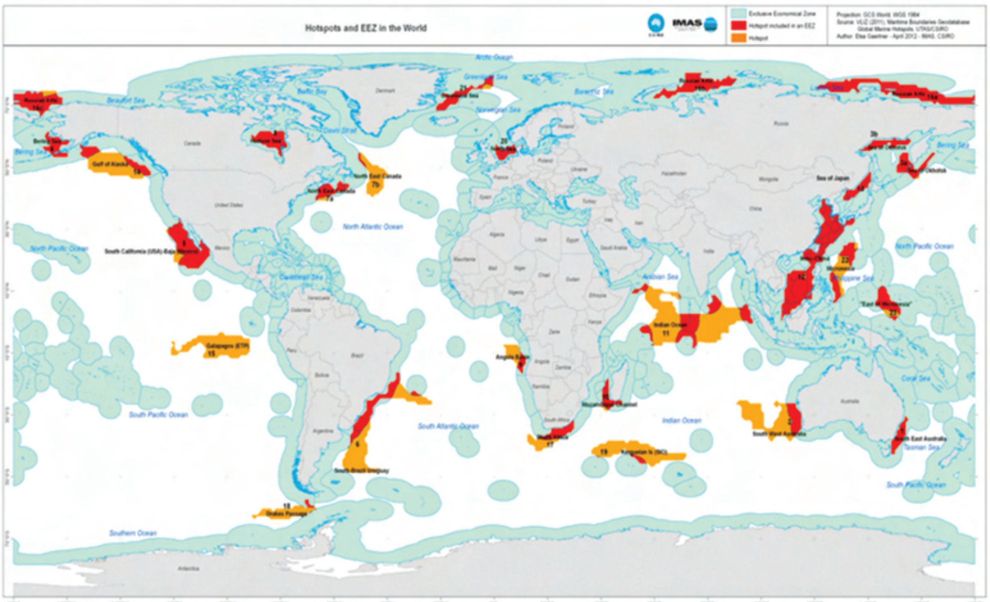
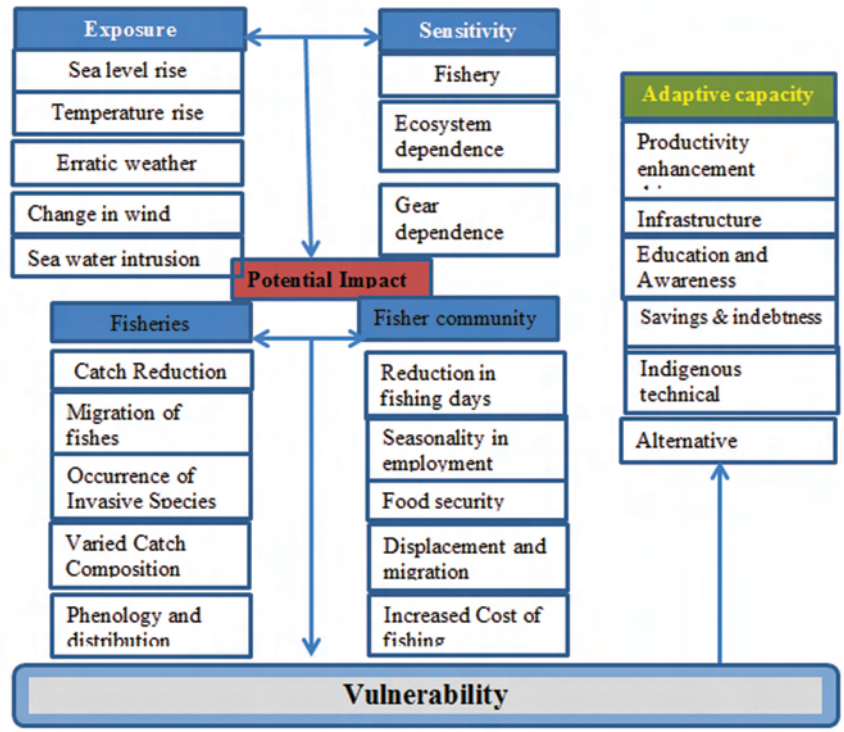


Fig.7. Hemisphere hotspots ocean regions experiencing fast warming and those with heightened social tensions as a result of change.

Vulnerability of coastal regions will be characterized using a linked socio-economic and ecological vulnerability model .The project will be in operation in the different hotspots and will lead to build regional skill-sets that can reduce coastal vulnerability by evaluating and characterizing likely impacts, create predictive systems that will inform decision makers about the expected consequences of coastal changes; deliver alternative options in terms of adaptation and transformation within coastal communities; and to define the long-term implications of selecting a particular option in terms of economic, social and environmental



(Modified form IPCC climate change vulnerability frame work)

Fig 8 . Conceptual Frame work of GULLS Fisheries Climate Change Vulnerability Assessment

outcomes. Thus, along Kerala, two major fishing villages namely Elamkunnapuzha of Ernakulam district and Poonthura of Thiruvananthapuram district in the south west hotspots of India was selected under GULLS project to assess the overall vulnerability of fishery based livelihood due to the impact of climate variation.

A composite vulnerability index approach was used in this study to evaluate relative exposure, sensitivity, and adaptive capacity (Islam *et al.,* 2014). 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 (Islam *et al.,* 2014).

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

The overall vulnerability values indicate that Poonthura village is slightly more vulnerable than Elamkunnapuzha . The proximity of Poonthura village to the sea can be attributed as the major factor contributing the increase in vulnerability compared to Elamkunnapuzha. In addition higher exposure on account of environmental changes, occurrence of drought and shoreline changes is also attributed to higher vulnerability in Poonthura. However, the sensitivity values are high in Elamkunnapuzha when compared to Poonthura due to high social dependence, economic dependence on other resources as well as historical and cultural dependence on fishing. The adaptive capacity of the selected villages were low when compared to exposure and sensitivity values, indicating the urgent need for developing appropriate adaptive interventions. Therefore, more adaptation options like better policy framework, proper planning measures, and effective disaster management techniques should be implemented to increase the adaptive capacity of the fishermen community to climate change. Improvement of natural capital like steps to curb marine pollution, maintaining prey-predator relationship in the oceans, promoting the culture of species in marine habitats (Cage culture), regulation of fishing rights across the Indian seas, extending the period of trawl ban so as to prevent the recruitment of juveniles entering the fishery maybe looked into as major elements while framing adaptation options.

CReVAMP' – "Climate Resilient Village Adaptation and Mitigation Plan"

A new framework titled 'CReVAMP' – "*Climate Resilient Village Adaptation and Mitigation Plan*" conceptualised for planning and implementing village level adaption and mitigation plan which is given in the figure no 9. Consistent with the project objectives, CReVAMP is developed to identify existing climate adaptation and mitigation- probing alternatives and their trade-offs, sensitizing and improving the resilience of community towards climate change and initiating a multi stakeholders platform for developing a climate knowledge and information systems. The 'CReVAMP' framework presents major elements and approaches through which the desirable outcome is envisaged across different players including individuals, community and the government. This also offers room for defining the 'elements' and 'approaches' in accordance with the village scenario and also for iterative planning of participatory as well as systems-based approaches under which different activities could be implemented with stakeholder engagement for achieving desirable outcome. Considering the sustainability of the adaption and mitigation activities even after the project period, involvement of the climate change agents in the entire process is vital and we have identified a group of people with representation from different age, gender and experience, encompassing articulate children, proactive youth, experienced fishers and committed women as climate change agents in the project. This framework is centered on people and it would help different practitioners to synergize their thoughts and ideas towards planning and implementing different adaptation and mitigation programs thereby helping the community to become climate resilient. In GULLS project we are adopting an integrated approach which would synergize the knowledge system of scientific and indigenous knowledge between the researchers and different stakeholders of the community. It is a balancing act between (i) 'Top Down and Bottom up Approaches', (ii) Prioritized needs of experts and felt need of the communities, (iii) Scientific Knowledge and Traditional wisdom,

(IV) Community Solutions and Policy Solutions. This process would be facilitated using multi stakeholder governance model by bringing different stakeholders together to participate in the dialogue, decision making, and knowledge sharing and there by instigate knowledge generation process within the community during the course of the process. The whole process is directed to create village information system within the community, enable green fishing practices and prepare A&M plan for a community which would in turn helps in community empowerment, thus enabling in building resilient community /Climate Change Informed Fisher Community (CCIF). The CCIF is 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.

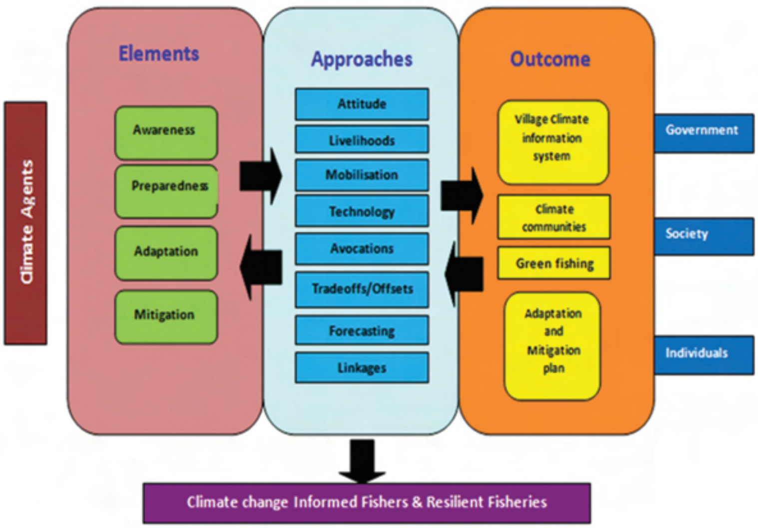


Fig. 9. CReVAMP Model- Climate Resilient Village Adaptation and Mitigation Plan

Various Phases are involved in the implementation of CReVAMP which are listed below in the table. These phases could be made operational with

Phase I	Identification of hot spot areas / districts/ delineation of villages
Phase II	Linkages with Department of Fisheries (DoF, Local Self Government(LSG)
Phase III	Conduct baseline and household vulnerability survey
Phase IV	Developing reports / Conducting awareness workshops / Engagement of fishers in climate change activities
Phase V	Creation of Climate Information Kiosks
Phase VI	Formation of climate change communities
Phase VII	Planning and implementation of Adaptation and Mitigation plans
Phase VIII	Climate resilient village adaptation and mitigation plan (CReVAMP) with Climate Change informed fishers.

Way Forward

Climate change is no unidirectional issue, it brings along with its effects on both the resources and resource users, thus the adaptation to it should ensure that the multifarious impacts it brings along can be tackled. Development cannot be ceased, nor can exploitation be hailed, the key to successful climate change adaptation is implementing sustainable development through incentive based polices and empowering the economically weaker sections of the society with environmentally friendly livelihoods. This could be achieved through 'blue economy' which is a recently developed business model which will shift society from scarcity to abundance "with what is locally available", by tackling issues that cause environmental and related problems in new ways. Blue economy could enhance the ocean technologies, provide marine governance, helps to improve ocean health and manage coastal urbanization. It is the marine based economic development which improves the human well -being and also social equity which in general greatly decreases the environmental risks and ecological scarcities.

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