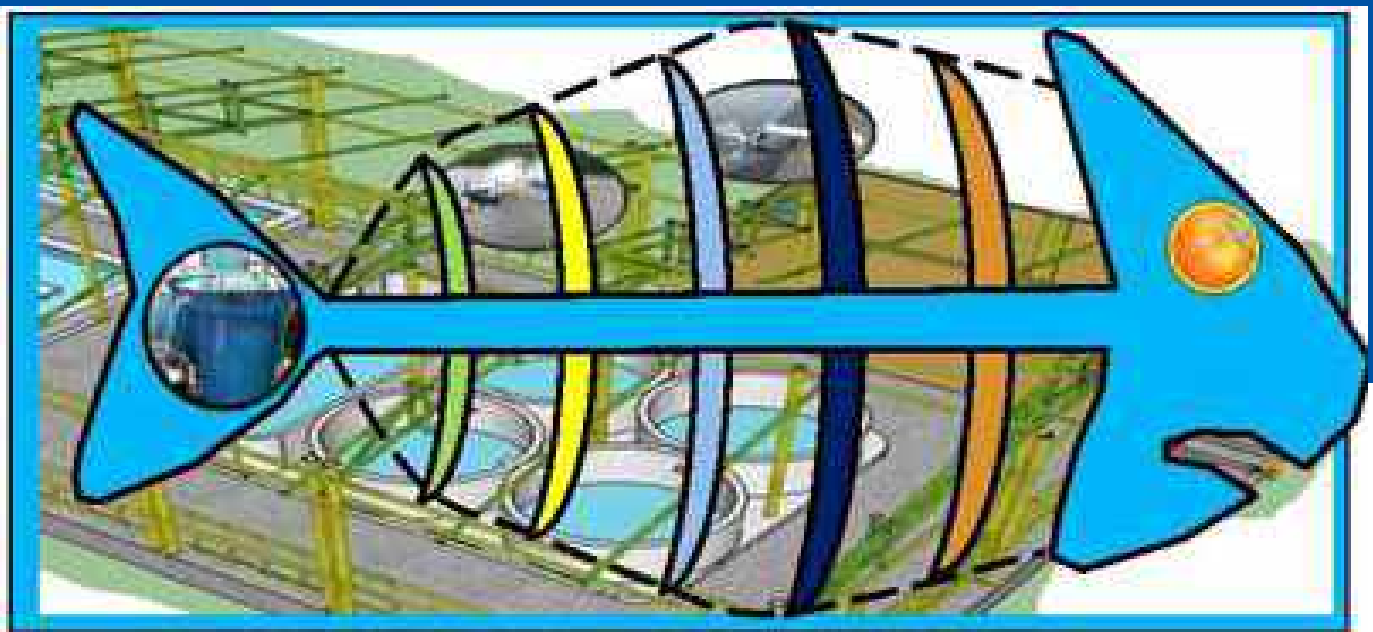


Precision Fish Farming: Automation Principles and Technological Solutions for Sustainable Aquaculture Production and Productivity



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CLIMATE CHANGE HOTSPOTS, VULNERABILITY ASSESSMENTS AND RESILIENCE OPTIONS - LESSONS FROM INDIA

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Introduction

Climate change is a global challenge today, with its impacts felt worldwide. 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. Even with extensive scientific research in this arena there is a lacuna in finding a panacea to this existing problem. Coastal environments cover 8 per cent of the world's surface, house 70 per cent of the human population, provide 90 per cent of the global fish catch, and deliver 40 per cent of the estimated economic value derived from ecosystem goods and services. In addition to increasing population pressure and demand for marine protein, climate change is modifying coastal environments and increasing the vulnerability of marine-dependent communities around the world. The effect of sea level rise means that coastal fishing communities are vulnerable and are in the front line of the deleterious effects of climate change. Changing seawater temperature and current flows will likely bring increases, decreases and shifts in the distribution of marine fish stocks, with some areas benefiting while others lose. These changes may have impacts on the nature and value of commercial fisheries. Many artisanal fishers are extremely poor with social and political marginalization with limited access to healthcare, education and other public services. With little capacity to adapt, the small-scale and migrant fishers are highly vulnerable to losses of natural capital consequent to climate impacts. The impacts of climate change affect the economy as well the social standards of fisher folk with implications for food security and sustainable livelihoods. Thus the climate change effects impact the environment, fishery, social, economic and development drivers. Consequently, it is important to understand factors that contribute to vulnerability of coastal biological and human systems in order to develop sustainable adaptation pathways; and develop effective mechanisms and expertise to translate findings into management guidelines and policy advice addressing natural, social and economic implications. Globally each government are looking for pragmatic time-bound strategies and plans for mitigation and adaptation.

Impacts of Climate Change

The climate changes impacts the marine ecosystem, resources and resources users at varying degrees. 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 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. 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. These processes in turn affect the distribution and abundance of plankton, which are food for small fish. Climate changes may, indeed, impact the near shore marine environment, as coastal areas are very sensitive to the strength and the variability of the meteorological forcing. 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. Fishes have evolved physiologically to live within a specific range of environmental variation, and existence outside of that range can be stressful or fatal. These ranges can coincide for fishes that evolved in similar habitats. Estuarine and coastal regions are extremely productive because they receive inputs from several primary production sources and detrital food webs. Temperature, along with other variables, causes active movement of mobile species to areas encompassing the preferred range of environmental variables, influencing migration patterns. The predicted increase in major climatic events, such as ENSO, may have drastic effects on fish stocks, especially when combined with other factors, such as overfishing. 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. The El Nino phenomenon generates substantial changes in oceanographic and meteorological conditions in the Pacific Ocean, with manifestations impacting the Peruvian coast, this has mainly affected pelagic resources, producing alterations in their biological processes, behaviour, and gradual decrease in their population levels.

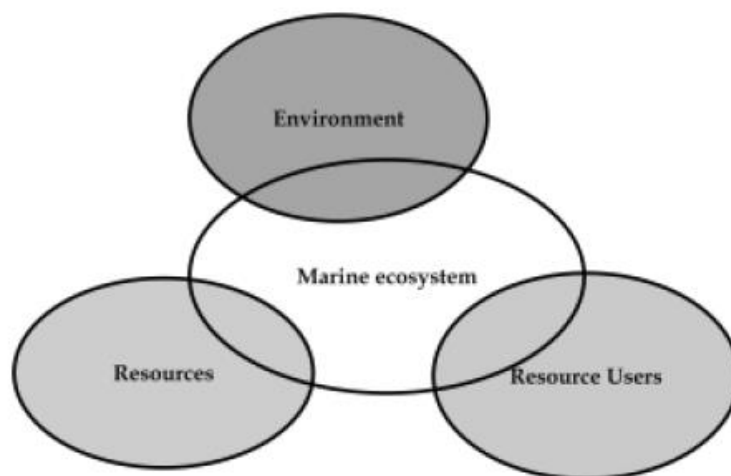


Fig. 1. Intricate set of relationships among environment, resources and resource users

Climate change will affect individuals, populations and communities through the individuals' physiological and behavioural responses to environmental changes. Extremes in environmental factors, such as elevated water temperature, low dissolved oxygen or salinity, and pH, can have deleterious effects on fishes. Suboptimal environmental conditions can decrease foraging, growth, and fecundity, alters metamorphosis, and affects endocrine homeostasis and migratory. These organismal changes directly influence population and community structure by their associated effects on performance, patterns of resource use, and survival. 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. Climate-driven fluctuations in regional temperature can further affect growth, maturity, spawning time, egg viability, food availability, mortality, and spatial distribution of marine organisms. 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. The studies carried on these 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.

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 fisher folk, fall in income level, seasonal employment, change in employment pattern, increased fishing cost, reduction of fishing days etc. (Fig. 2).

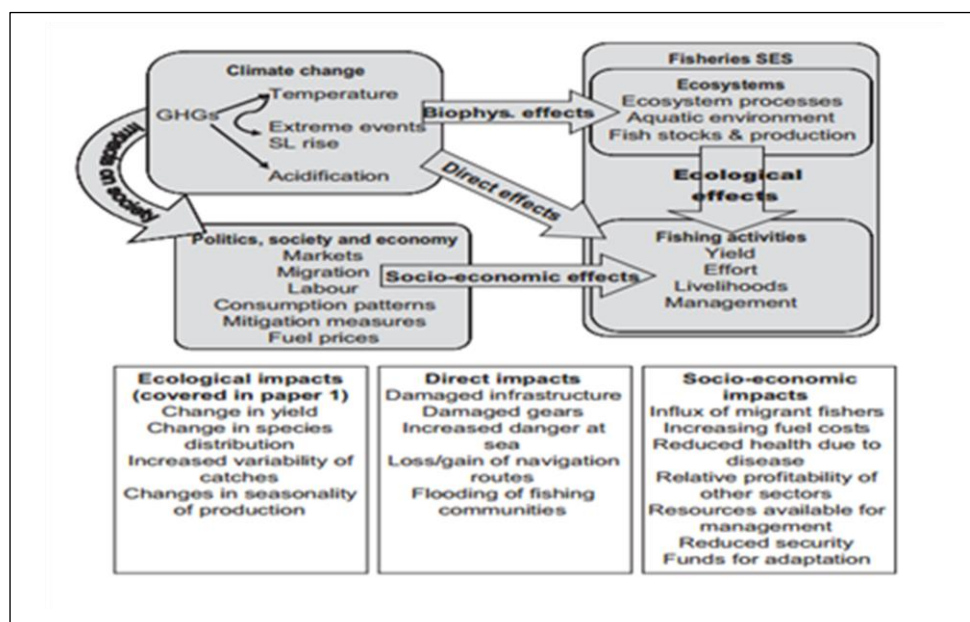


Fig 2. Ecological, direct and socioeconomic impacts of climate change on fisheries

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. The coastal regions around the 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.

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.

Climate hotspots and the Belmont Forum

The climate hot spots in climate change parlance have not been identified yet in Indian context, it was high time to define and identify climate change hot spots in India to initiate comprehensive planning for adaptation and conservation measures. 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 will help policy makers in priority setting and in planning adaptation and conservation measures. Under the changing climate scenario and its impact on the socioeconomic status of the coastal communities of India, the project titled “Global understanding and learning for local solutions: Reducing vulnerability of marine-dependent coastal communities” was proposed by CMFRI and sanctioned under the MoU of Belmont Forum and G8 Research Councils International Opportunities Fund. The project was focused on revamping the coastal livelihood sustenance by predicting the suitable adaptation possibilities for the future years towards rising global warming and population density. The project contributes for improving community

adaptation efforts by characterizing, assessing and predicting the future of coastal-marine food resources and identification of suitable adaptation options. The overall project objectives were 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 outcomes.

The 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 contributes for improving community adaptation efforts by characterizing, assessing and predicting the future of coastal-marine food resources and identification of suitable adaptation options. The overall project objectives was 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 outcomes.

Consistent with the objectives of GULLS, activities were developed aiming at assessing the current status of the fishery resources and ecosystem services and 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 hotspot region of South India (South West and South East Region of India). The study area included the South East India encompassing Ramanathapuram and Tuticorin districts of Tamil Nadu was one of the Hotspot and the other be South West India (coastal districts of Kerala including Ernakulam, Alappuzha, Kollam and Trivandrum) with fisheries abundance and distribution shifts.

Initiative and Interventions

The Assessment of fishers' perception in developing climate change adaptation and mitigation plans was the pilot study of the project and it analysed the scope of developing village level adaptation and mitigation plan for the community through a comprehensive analysis of the community perception on climate change impacts, vulnerability and existing adaptation mitigation strategies and derived at some relevant conclusions. In the chosen study villages of Ochanthuruth and Narakkal of Ernakulam district, the impact of climate change was felt on both resource and resource users based on a perception analysis made using comprehensive interview schedule administered across 300 households. The study revealed that the actual science and consequences of climate change impacts in a long run are not

perceived well. The work suggests that concerted efforts in bringing about resilient community can be achieved through global understanding of the issue and coming up with area specific solutions with the inclusion of the much forgotten social factor- the stakeholders. The suggested adaptation and mitigation options by the community towards reducing the impact of climate change include environmental measures economic measures/options for alternate avocation, social measures and development drivers. The results indicates that under environmental attributes, community's major priority was given to construction of (64.96 percent in Ochanthuruth and 84.78 percent in Narakkal) seawall along the shoreline to contain the impact of sea level rise. Since majority of the respondents were residing within 100 meters of shoreline, they believed that a seawall would protect their habitat and households from sea level rise and high tide. Paradoxically, it is a fact that seawall construction has an implication on the shoreline as it induces artificial sediment transport which leads to uncontrolled erosion and accretion. Options for livelihood diversification were desirable by 16 percent of the total respondents. It was observed that fishing was not an attractive and lucrative profession while considering the risks and uncertainties, especially to the youngsters; a clear shift to non-fishing activities like carpentry, masonry and coolie work was evident. Additionally, the existence of Kudumbashree self-help groups offers ample scope for initiating further income generation activities for the women fisher folk. Mangrove planting was an option suggested by 50 percent of the respondents to reduce the impact of climate change. Knowingly or unknowingly many households have already adopted mangrove planting as a measure of bio fence in protecting their habitat. Besides being a bio-fence mangroves have an incredible scope for developing alternate avocations, as it provides breeding ground for many fishes. According to 33.3 percent of the respondents from Ochanthuruth and 43.48 percent from Narakkal, pension was considered a good adaptation option for the traditional fisher folk. Apparently, they felt that the amount they were getting was very minimal and that there was a necessity to increase the pension amount in accordance with the fluctuations in the living costs within the society. Thirty two percent of the total respondents requested for trainings and awareness programs on climate change issues, which would thereby widen their horizon of knowledge on the issues pertinent to their life situations. Moreover better infrastructure facilities including good roads and transportation facilities, improved public health facilities and proper drainage were crucial in mitigating the impact of climate change according to 31.17 percent of the respondents. Improved safety and communication measures were also considered important in mitigating the climate change impacts according to 5.67 percent of the respondents. Awareness creation on climate change is a prerequisite to kick start any adaption and mitigation measure in any community. In order to have comprehensive adaptation and mitigation plans for the entire community, it is important to synergize the scientific and indigenous knowledge system of researchers and different stakeholders of the community. Moreover, it is 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. Furthermore, innovations would be possible in the areas like

development of new fishing methods and fish farming activities, options for alternate avocations and livelihood enhancement program for the family, improved weather forecasts, energy.

The climate change has multidimensional impacts on environment, fishery, social, economic and development drivers. The study on “Climate Change Impacts on Livelihood Vulnerability Assessment-Adaptation and Mitigation Options in Marine Hot Spots in Kerala “ assessed the climate change vulnerability of over 800 fisher households in two major fishing villages of Kerala from the south west hotspot regions of India. Exposure (E), Sensitivity (S) and Adaptive Capacity (AC) are the pertinent factors that determine the vulnerability of households which were captured using a structured household questionnaire. One ninety eight indicators were identified in the construction of vulnerability indices of which 37 related to sensitivity, 36 related to exposure and the other 125 indicators dealt with adaptive capacity. The overall vulnerability of the regions was assessed and the analysis revealed that the Poonthura village of Kerala was more vulnerable when compared to Elamkunnapuzha. The coastal population on their vulnerability scores were categorised into low, moderate, high and very high based on score values and geo-spatial analysis was attempted. The results revealed that majority of fisher households in both villages were highly vulnerable to climate change, which is a major cause of concern. The study advocates the need for a bottom up approach with the proactive participation of the fishers in developing location specific adaptation and mitigation plans to ensure the livelihood of the fishers and the sustainable development of the fisheries sector in the climate change regime.

The analysis on the impact of climate change on resources and resource users for community concerns for present and future was one of the other prime area of concern of the study. In the chosen study villages of Ochanthuruth and Njarackal of Ernakulum district, the impact of climate change was felt on both resource and resource users. Where, resource primarily includes fishes and resource users indicates fishermen. Three hundred respondent households were chosen for the study and the results points out that a large proportion of respondents indicated that the local climate has been altering since their childhood. Almost all the respondents agreed that climate change is affecting them. However they felt the impact differs. 97 percent of the respondents were of the opinion that the temperature rise (excessive heat) is the greatest affecting variable in the context of visible features of climate change, followed by changes in wind pattern (65 percent), sea water intrusion (40 percent), availability of water (35 percent), erratic weather (20 percent). The study is in sync with George (2010) where he observed that the fish farmers perceived climate change effects from sustained changes over time in environmental temperatures, rainfall intensity as well as pattern and also wind variability. The respondents expressed their discomfort in context with the temperature rise when compared with the previous years. The uneasiness was explained in terms of profuse sweating and heat during the day hours and the lack of sea breeze during the night hours. They anguished their dependency on electricity, as it was impossible for them to live without fans, this also added extra burden in terms of their increased electricity

bills. . Majority of the respondents claimed that climate change was the result of human activities, rather than a result of natural variations. 72 percent of the respondents strongly believed that climate change is due to the aftermath of industrialization and subsequent urbanization, habitat destruction, pollution and transportation etc. Reduction in fishing days was also considered as another major impact of climate change according to the respondent fisher folk (72.22). They further explained that, fishing operations were gradually becoming non-profitable due to diminishing returns and is not sufficient to meet even the operating costs. Consequently there was a tremendous drop in the average number of fishing days. Fishing labourers, who share one third of the total revenue of the catch, suffered heavily with substantial wage losses due to decrease in catch.

The impact of climate change has led the study area in becoming vulnerable, based on the principle factors of sensitivity, adaptive capacity and exposure. The first step in accomplishing a society to become resilient to climate change is to make awareness on the same. The study found that though more than 89.6 percent of the respondents heard about climate change through various forms of mass media, *viz.* print and audio-visuals, and through word of mouth, their awareness seem to be very shallow. This may be due to the fact that, fishers could not correlate the changes in their environment to climate change, but with further probing it was found that there were many visible parameters that they complied with, which was felt as possible reasons for climate change, the reasons being temperature, change in wind pattern, sea level rise, sea water intrusion etc. On further inquiring, it is found out that the issues in the day to day life as well as fisheries sector which the respondents connects with climate change, may not necessarily be true with regard to climate change process. This is because, many issues of the fisher folk were overlaid with climate change issues and by which they could easily identify their concerns of the present and future in relation to climate change. However, in-depth knowledge is required to find out interlinkages of climate change issues in their life, and there by developing adaptation mitigation plan for the community. Hence imparting awareness on climate change among different communities is the need of the hour to make them involved in developing adaption and mitigation plan for the community.

The socio economic profile of the Poonthura village of Thiruvananthapuram district, Kerala where fishing is the most important economic activity was assessed and the results indicate that among the 222 fishing villages of Kerala, Thiruvananthapuram has the maximum number of marine fishing villages (19 per cent) where in fishermen reside. Poonthura village is one of the major fishing villages from the South West hotspot regions of India, situated in the suburbs of Thiruvananthapuram district, the capital of Kerala. The study analyzed various socioeconomic aspects such as the fishing activity, basic household data, economic as well as historic and cultural dependence on fishing, gender equity, employment and occupational structure, community infrastructure, income distribution and assets, physical capital, financial capital, social capital, and exposure of the fishermen families by taking 500 samples from the study area. Even though the village is having a century old fishery culture and a strong

emotional attachment to the fishing job, people are not ready to direct their young generation into this sector which indicates the higher level of vulnerability prevailing in the sector. The study as the first of its kind conducted at one of the most vulnerable marine hotspot of Kerala and which explains the problems, prospects of the inhabitants in the sector has its own relevance as a basis to develop proper adaptation mitigation strategies for the fisher folks by analyzing the data collected from the 600 fishermen selected randomly from the village, a clear picture of the socio economics status of the fishers is presented in the study. The results indicated that fishing is the major economic activity of the village and the whole population are fishers. Even though the village is having a century old fishery culture, people are not ready to direct their young generation into this field. This indicates the vulnerability of the sector. More than half of the respondents (54 per cent) believe that being independent is the good thing about being fisher while 38 per cent thinks that it is the best thing. A very high emotional attachment to the fishing activity is found among the respondents as 63 per cent of them reported that they are very proud to introduce themselves as a fisher. Still, the scarcity of resource and the uncertainty of the job are making the fishermen to turn away their coming generations into some other fields. The results point out the reduction in the fish resource as the major reason for the uncertainty in a fisher's life. Many changes are visible in the fishing activity over the years in terms of the availability of species, fishing grounds, etc. In regard with the occupational flexibility, the study shows that a major share of the fishers don't know any other jobs. Around 87 per cent of the respondents are having at least primary level school education. Most of them are ignorant about the governmental provisions and supports. Even though they are working in very risky situations, more than half of the respondents (58 per cent) are not having any types of insurance, according to the study. The study revealed that almost 90 per cent of the respondents are earning within Rs 10,000 per month, but still a better share (89 per cent) of them reported that they are not having any savings or money put aside for emergencies. About 80 per cent of the respondents are having mortgage on their house and around 83 per cent of them owe money to someone.

The income inequality measured with the help of Lorenz curve resulted a Gini coefficient of 0.495 which indicated a noticeable level of income inequality in the community. In regard with the food security, 91 per cent of the respondents are having fresh fish daily as a meal, and may be due to that a lion's share (81 per cent) of the respondents are not having anyone in their home chronically ill. All of them are possessing most of the basic amenities in their household assets, still hygiene is a luxury in the locality. More than half (53 per cent) of the respondents are following improper management of the waste water and rubbish. Proper awareness campaigns have to be carried out to protect the locality. According to the study, around 37 per cent of the respondents are interested in learning new ways to improve their business skills. This indicates that there is ample scope to increase the income and thereby the living status of the fishers by providing proper knowledge about the improved fishing and fish culture practices on scientific basis.

Way forward

Fisheries and allied sectors provide means of livelihood to millions of people around the world. In India more than 14.5 million individuals depend on fisheries for their livelihood, with Gujarat, Tamil Nadu and Kerala being the main three marine fish producing states of the country. The social and economic contribution of fisheries as a sector cannot be ignored or go unnoticed. Similarly the impact of climate change on fisheries and its resultant impact on the livelihood of fisheries dependent communities cannot be ignored. To address these pertinent issues, we first need to understand the impact of climate change on fisheries and the need of alternative livelihood options. From this perspective of the direct stakeholders i.e. fishermen. A study was conducted to look at the need of Alternative livelihood options (ALOs) among the fishing community in Poonthura and Elamkunnappuzha villages of Thiruvananthapuram and Ernakulam. The study investigated different socioeconomic aspects, for example, fishing activity, basic household data, economic as well as historic and cultural dependence on fishing, employment and occupational structure, income distribution and assets, physical capital, financial capital, social capital, and exposure and awareness of the fishermen families to climate change by taking 1259 samples from Poonthura and Elamkunnappuzha. The study conducted in the most climate change vulnerable marine hotspots of Kerala (Elamkunnappuzha and Poonthura) explains the problems and prospects of the inhabitants in the sector and the importance of Alternative Livelihood Options (ALOs) in climate change adaptation.

The study points out that climate change is something that can affect the coastal community at multidimensional levels, the most important being their livelihood. Right to livelihood being a fundamental right, is something that is guaranteed to every citizen of India. So it is important that the researchers and policy makers work hand in hand to make this changing situation a boon. According to the study, 32 per cent from Elamkunnappuzha and 19 per cent from Poonthura have Alternative Livelihood Options whereas 61 per cent from Elamkunnappuzha and 67 percent from Poonthura have no Alternative Livelihood Options other than fishing. From this we can conclude that majority of the respondents are completely dependent on fisheries and has no other means to survive, if left without it. Daily wage labour, SHG, Small scale industry, Service Industry and Masonry/carpentry are the top five ALOs preferred by fishermen in Poonthura and Elamkunnappuzha fishing villages. Climate change has already been experienced in many parts of India with several seasons of intense storms, droughts, floods, fires etc. Any further delay in addressing the issue would put at risk many more lives, livelihoods and investments for decades to come.

The increasing ALO scenarios of shifting from fishing to other job sectors and the diminishing number of younger generation in the fishing industry necessitates the need for assessing the Changing Rationale of Fisher Youth. The Indian fisheries and aquaculture statistics largely fail to capture the youth and children working in the sector. A detailed study in the area related to the rising interest of fishermen, especially the younger generation to move out of fisheries in search of new opportunities in other fields and the reasons for the

same has not been carried out. Taking this into consideration, to throw insights into the changing rationale of fisher youth, a study was conducted in three coastal villages of Ernakulam district with the objectives of assessing the socio-economic profile of the fishermen, younger generations interest in choosing fisheries as a livelihood option, generational shift in fishing operations and reasons for the disinterest of the younger generation in choosing fisheries as an occupation. Low status job, low profit and income, poor working conditions, high capital investment and operating cost and seasonal nature of occupation were reported as the five major reasons because of which the younger generation is not interested in choosing fisheries as an occupation and a considerable generational shift in social, economic and professional status was observed.

The carbon emission attempts was one of the most important part and reveal that fisheries contribute to global greenhouse gas emissions (GHGs) during fish capture or growth, processing, transportation and storage. The study reveals that the Indian marine fishing scenario is not at its best in terms of sustainability and coping with climate change. This can be explained due to uncontrolled growth in the mechanised sector. Just like how industrial revolution at the dawn of the 19th century brought unimaginable development within a short span of time but led to pollution and other anthropogenic issues. The mechanised sector in India is leading the fisheries sector to a plateau of stagnation. The traditional fishermen who have been thriving for centuries have now lost hold in their own regime. Even with policies such as closed fishing seasons, which allows traditional fisherman to fish while the mechanised sector is forbidden to venture into the sea, the situation hasn't bettered. Not only is it a socio-economic crisis but it is also an environmental deadlock. With the increase in fishing fleets, which venture deeper and deeper into the oceans unsustainable fishing is but evident, usage of trawl nets and other high end gears has led to increase in by-catch during fishing and also led to the fishing of spawns.

However on an international platform, India's position is much brighter. Globally there are many different kinds of fisheries with many different fuel requirements. These range from small low-power single engines to larger vessels to fish factory ships. One of the primary differences between fuel-use in developed and developing-country fisheries is fuel efficiency, where the proportion of revenue spent on fuel, with developing countries spending up to 50 percent of total catch revenue on fuel ¹⁰. Fuel emissions from fishing vessels, product transportation are the main source of emissions in the fisheries sector. Products are typically transported via freight on ships or plane, especially if they are moving from developing countries to developed-country markets

In addition, fisheries management contributes to some of this inefficiency with policies that create a "race to fish". This refers to policies that inadvertently create incentives for more powerful engines to catch more fish, which can quickly lead to overfishing. Vessels then have to travel farther or to deeper waters and spend more to catch the same amount of fish as they have in the past. In order to better the situation in terms of social upliftment of the traditional fishers as well as bringing environmental tranquillity, the concept of green fishing needs to be

popularised, and supported with incentive based policies. Pricing the marine fish caught based on the method of fishing, and selling them with a green tag, which suggests the emission they have contributed, can be a precursor for a large movement in the fisheries sector. Once this idea gains popularity, it can be scaled up at a global level and can work on the basis of Kyoto Protocol, where Annex I parties can pay in terms of CER (Certified Emission Reduction) to Annex II parties. This will lead to traditional fishers benefitting, as well as will reduce emissions in the fisheries sector at large and achieving a fishery induced blue carbon economy. These made integrating climate change and blue economy in fisheries research and education in India as one of the other major thrust of the project.

To determine the common trends in abundance of marine fishery resource abundance in South Kerala Coast and investigate about the influence of environmental variables on resource abundance and its economic impact biological studies have been carried out. Statistical multivariate time series modelling tools such as Dynamic factor analysis, Predictive modelling, Ecopath and Eco sim has been done to arrive at meaningful conclusions. The common trends in landings of resources, contribution of climatic variables towards the common trends, the marine fishery resources were classified into distinct groups based on the dynamics in landings and relationship with climatic variables. Initial studies have shown that among the coastal regions in India, the southwest coast comprising the coastal districts of Trivandrum, Kollam, Alappuzha and Ernakulum in Kerala state are likely to be affected by climate change. This region is one among many hotspot regions globally identified as locations predicted to warm substantially faster than the global average. This region is highly productive in respect of marine fish harvest with landings of around 270 species every year by mechanized, motorized and non-motorized fishing crafts based at 105 marine fish landings centres including fisheries harbours. A population of about 3.4 lakh marine fishermen belonging to nearly 75,000 families spread in 119 marine fishing villages in this region, solely depend on fisheries for their livelihood. Changes in availability of marine fishery resources will adversely affect this economically backward group of fishermen leading to social issues. It has examined the changes that have happened in the composition and dynamics of marine fisheries resources landed in this region and its relation to climate change. The effect of climatic variation over years on the fishery of this region was evaluated using historic multivariate time series data on resource wise marine fish landings and climatic variables such as sea surface temperature, atmospheric temperature.

The project addressed all the proposed objectives with the fruitful outcomes and on the final notion of progress, the potential complexities of climate change interactions and their possible impacts in mainstreaming the cross-sectorial responses into governance frameworks was developed reviewing the global and national climate change conferences and policies and with the available literature, using a livelihoods framework. Pathways were identified through which climate variability and change impact the fisher folk livelihoods at the household and community level. An integration framework called CReVAMP (Climate Resilient Village Adaptation and Mitigation Plans) was planned and to be established with

inputs from the grass root level multi-stake holders, local self-governing bodies and government consortia. The strategy was conceptualized 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” which is 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, which is directed to create village information system within the community, enable green fishing practices and prepare adaptation and mitigation plan for a community which would in turn helps in community empowerment, thus enabling in building resilient community /Climate Change Informed Fisher Community (CCIF) and 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.

A conceptual framework encompassing the different indicators components fitting the vulnerability assessment using sensitivity, adaptive capacity and exposure was developed to arrive at socio ecological vulnerability. A climate change integration and synthesis framework using drivers resilience (environmental, species/resource resilience) coupled with exposure, sensitivity and adaptive capacity to arrive at social resilience and adaptive capacity in identifying opportunities and government effectiveness was also developed. This core framework can be pertinent towards decision making and arriving at inferences on adaptation, prevention, conservation and mitigation policy planning and priority recommendation measures. Aforementioned improvisations and recommendations on climate change policies are a welcoming factor by marine-dependent coastal communities, which indeed will be effectively perceived and adapted for their better sustenance and development in the future in contrary to the changing climate events. Policy mapping document for Indian fisheries sector was developed and a balancing of results approach methodology was developed for planning climate change adaptation and mitigation. Numerous overflow proposals were developed and submitted for funding in addition to developing linkages with local self-governments, national and international research organizations.

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. Implementation of eco clubs from local level student groups has to be initiated to increase participation in environmental conservation promoting sustainable environment. They can act as climate change agents in the society by creating awareness (climate literacy) among the different communities. Conducting afforestation programmes in the urban areas to restore greenery and finding alternative livelihood options for strengthening the value chain against climate change is in prime concern with a motto of “Think globally, Act Locally & Live responsibly” –towards conserving the environment for the future generation.

Outcome/ Output

The research project on Global Learning for Local solution funded by the BELMONT forum funded during 2014-19 was implemented across the climate hotspot regions of South India. The project was conceived and implemented with works across the multi-disciplinary theme areas of biology, modelling, environment, social, economic, policy and communication. In addition to the involvement of CMFRI Scientists, 18 research scholars and contractual staff gained exposure and training in the different project theme areas and are successfully placed after the project period. The major outcomes of the project includes excellent research publication in reviewed journals, new overflow proposals, development of instructional materials -Climate Education (ClimEd series) aimed at climate literacy, creating awareness and imparting training, developed predictive modelling on the impact of climate change on fisheries resources, considerable research collaborations with international research and development agencies, strengthened linkages with government agencies including local self-government., climate change awareness and dissemination to stakeholders, climate change as a science has been transferred to fishers and socioeconomic impact assessments perpetuated into tropical fisheries sector, efforts on incorporating climate change domain into the LSG planning and implementation, identified possible climate change champions in experienced fishers, committed women, articulate children and proactive youths – towards creating climate awareness, literacy and training, integration framework called CReVAMP (Climate Resilient Village Adaptation and Mitigation Plans) was planned to establish with inputs from the grass root level multi-stake holders, local self-governing bodies and government consortia, identified possible alternative livelihood options for the fishers, improvisations and recommendations on existing climate change policies for marine-dependent coastal communities, which indeed will be effectively perceived and adapted for their better sustenance and development in the future in contrary to the changing climate events and dissemination of study results in various national and international platforms. The Indian case studies continues to be an example for assessing socioeconomic vulnerability assessment and in developing adaptation and mitigation plans across other developing/ tropical fisheries countries.