# Assessment of Coastal Vulnerability to Climate Change:

## *A Case Study of Ernakulam District, Kerala*

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***Abstract:*** **The vulnerability of fishing community towards the climate change, being a subject of great concern all over the world, takes the form of social, economic and even geographical and biological issues.This paper addresses the relationship between vulnerability of fishing communities to climate change in Kerala.The study indicated that fishers' response to climate changes was in consonance with real time changes in the environment, with regard to temperature rise, rate of pollution, the change in wind pattern as well other ocean parameters. It was also noted that the long term effects of climate change weren't felt much among the fisher household.**

***IndexTerms*** **- Vulnerability, Sustainable development, Climate Change, Natural Degradation, Fishing Community, Vulnerability assessment**

### I. INTRODUCTION

Climate change being the buzzing word of the hour, have gained a lot of attention from all over the world, from all stakeholders, administrators, politicians, environmentalists, scientists, scholars and even the technocrats. For centuries, atmospheric carbon dioxide had never been above about 300 parts per million. However, the current level being 400 ppm, owing to the escalation in integration of technology in almost every aspects of human life. i.e., the harsh impact of the industrial development and the resultant fast urbanisation of the world. Global warming, being the rise in the average temperature of the Earth's surface and its atmosphere, is the most closely related aspect of climate change, being both its cause and result. The greenhouse gases, emission, aerosols and soot, solar activity all being the causes of it. The outcomes of this phenomenon being sea level rise, sudden and extreme weather fluctuations, climate changes, ecological imbalance, and other long and abrupt impacts. All of these, being the repercussions of one another, often creating imbalance in the vulnerable ecology and even human lives, like inundation from sea level rise disturbing the infrastructure and human settlements.

Fishing communities being the most vulnerable in this category, faces a lot of harmful backwash effects of the same. Fisheries, being the important contributor to food security and livelihoods are responsible for providing essential nutrition for 3 billion people and about 50% of animal protein for people in the poor countries.The fishing sector in third world countries are more vulnerable when compared to that of developed nations who have better tools and means to exploit the resources. The climate change can have the impact on changes in various aspects affecting the fishing activities, namely, the availability, stability, accessibility and utilization. India, being a peninsular country, and fishing, being a major industry of the coastal states which employs over 14 million people, the fishing communities here, are undeniably susceptible to after effects of climate variations. Riding on a robust demand for its frozen shrimp and frozen fish in international markets, India exported 11,34,948 MT of seafood worth an all time high of US$ 5.78 billion (Rs 37, 870.90 crore) in 2016-17 as against 9,45,892 tons and 4.69 billion dollars a year earlier, with USA and South East Asia continuing to be the major importers while the demand from the European Union (EU) grew substantially during the period.(MPEDA 2017)

The vulnerability of fishing community towards the climate change, being a subject of great concern all over the world, takes the form of social, economic and even geographical problems. "A coastal area profile presents a variety of information required for effective decision-making and planning, including environmental and socio-economic information and the analysis of problems and opportunities for sustainable coastal development" (FAO). Fishing has been considered as a primary livelihood option since time immemorial, for the occupants of the coastal belt in India, stretching along 8129 km.

Fisheries sector play an important role in the economic activity of the nation, through its contribution to national income, foreign exchange, food and employment. About 12.49 lakh fisher folk operate using diverse types of craft-gear combinations with regional and seasonal variations all along the Indian coastline. The secondary sector provides employment to more than 15 lakh people and another two lakh people is employed in the tertiary sector. It is estimated that fishery and allied activities provide livelihood security to about 30 million people (Sathiadhas et al, 2007). The density of population is very high all along the coastline as compared to the midlands and the highlands (Asia Development Bank, 2003). Kerala was made a leading producer and consumer of fish, due to the presence of a very rich marine wealth with a large variety of fish and a highly skilled population of (Aerthayil, 2000). Kerala, being an important exporter of marine products and host of various fishing communities is also facing a crunch due to both uncontrolled fishing activity, the resultant over exploitation of resources,environmental pollution as well as the effects of climate change.

## II. VULNERABILITY ASPECTS AND FRAMEWORK

The conditions, situations and indicators related to the vulnerability framework and concepts takes the following aspects and dimensions, including geographical, social, environmental, technical, sectorial, equity related, policy related , gender specific, and so on.

Along the coastal areas, coastal erosion and the measures taken to control it have together led to the loss of several beaches. The barrier beaches & backwater islands of Kerala are very sensitive environmentally, socially and economically as a large population depends on the system. The communities in most of such island systems are ecosystem people who depend on the natural island system for their survival. Degradation of resources, uncertain employment and earnings, limited livelihood assets and subsistence almost entirely from fishing impacts these community's livelihood options. Rao et al., (2005) and, Beck and Nesmith (2001) argue that there is a need to give greater attention to the role of Common Property Resources (CPR) in poor people's livelihoods. Non-motorised boats with low mobility for comparatively poor fishermen also adds to the problem of catch fluctuations.The sole dependence of people on marine fishery for their livelihood itself is a major challenge. The stock of resources is reported as depleting and the resulting conflict prevails between the traditional fishermen and the capitalists. The policy connected with deep sea fishing is allegedly making distress to fishermen. Most of the fishermen are severely indebted, addicted to alcohol & drugs, under educated and lacking skills for alternate employment. It helps occasionally in mushrooming of the illegal activities and attracts more and more unemployed youth. Darkened expectation in life, illiteracy, lack of awareness & counselling support, rising influence of alcohol and drugs, rise in communalism and criminal tendencies, etc. are some of the reasons for such social issues. On a whole, backwardness becomes the hallmark of fisherman. This vicious circle of poverty needs to be broken so that a virtuous circle of prosperity is set in motion by 2030. (John Joseph, 2015). Consequently schooling on one hand result in putting the out of their traditional occupation and also the dropout rate is higher in fisher folk. (John Kurien, 1981).So, the people have limited alternative skills other than the traditional fishing activities.

"Increased incidence of extreme events such as storms, floods and drought will affect the safety and efficiency of fishing operations, flow of rivers; area covered by wetlands and water availability and will have severe impacts on fisheries. Sea level rise will have effects on the coastal profile and livelihoods of communities. The potential outcome for fisheries may be decrease in production and value of fisheries, and decline in the economic returns from fishing operations". (E. Vivekanandan). Inter-governmental Panel on Climate Change 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 (IPCC, 2007).

It is the open-access or common property nature of the sea that attracts large numbers of poor people to find their livelihoods there, and they are badly affected when the terms of access to the resource change. Open access allows the entry of bigger players into the sector, which come to dominate or even monopolize access to resources – often with the facilitation of the state – and marginalize traditional stakeholders. Development efforts have given rise to a hierarchy based on economic criteria in the villages. The diffusion of new technologies has benefited a few people, with the large majority becoming wage earners and several others becoming redundant. Changes in marketing patterns brought about a change in sharing patterns, transforming fishing crew from shareholders to employees, although they still retain a share in the catches. (Venkateshsalagrama).

About the societal issue faced by the fishing communities due to climatic change, the primary challenge to the fisheries and aquaculture sector will be to ensure food supply, enhance nutritional security, improve livelihood and economic output, and ensure ecosystem safety. These objectives call for addressing the concerns arising out of climate change, and evolve adaptive mechanisms and implement action across all stakeholders at national, regional and international levels ( Allison et al., 2004; Handisyde et al., 2005; Leary et al., 2006; World Fish Center, 2006; FAO, 2008). In response to shifting fish population and species, the sector may have to respond with the right types of craft and gear combinations, on-board processing equipments etc. Governments should consider establishing Weather Watch Groups and decision support systems on a regional basis. Allocating research funds to analyze the impacts and establishing institutional mechanisms to enable the sector are also important.(E.Vivekanandan). For instance, Coastal Regulation Zone notification is perceived as being partially effective, trawl ban is considered to be effective.

Trade policy tools like tariffs, subsidies and standards, can also affect the fishers. Likewise, a major problem of competition with more powerful forces, coupled with the community based governance systems and the absence of institutional mechanism among the fishers, can be addressed by promoting cohesion within the fishing communities, imparting awareness about new laws and schemes that which restrict or promote the fishing activities and to encourage capacity building. On a different note, adaptive capacity can be increased through equal distribution of resources. It is related to the resource conservation and participation in management, which are in turn linked to the aspect of technology of harvesting, certain historical rights and even certain value premises. Within each zone of Kerala coastline, geography, fishery resources, infrastructural and mechanical facilities and market access are relatively same. Thus, the fishing community can have greater involvement in the development and conservative management of fishery resources with the united efforts of active fishermen, social workers, social and physical scientists and voluntary associations concerned with socio-economic and ecological issues. However, artisanal fishermen are more affected, leading to poverty. Open and regulated access to new technologies can be emphasised.

On the gender perspective, the fisherwomen in Kerala play an important role in the fisheries sector in terms of their involvement in fishery related activities viz., fish vending, fish drying, prawn peeling, sorting, grading, fish packing, and net making. However, they are more vulnerable than men in receiving the after effects of the impacts. The highest level of gender discrimination faced by all the respondents across the four different occupational groups were in handling, transporting and storing bulk quantities of fish resources. "Micro enterprises and SHGs linked to any financial institution in order to obtain credit facilities, like RashtriyaMahilaKosh, NABARD, banks; can be assisted technically or financially by local self-government or NGOs, GramaPanchayat, Municipalities, Corporation, or resource departments. The flagship programmes of SAF, and the Theeramythri mainly aims at the social and economic emancipation through encouraging employment. This can act as a great relief for BPL fisherwomen, who does jobs like vending and trading of fish, apart from household support, as it helps to achieve a financial stability;

and non SHG members, can organise occupational ones to start micro enterprises. In Kerala, 80% of the income generating groups were formed by the women beneficiaries. Similarly, Mahatma Gandhi National Rural Employment Guarantee Act was implemented, with over 91% beneficiaries as women in Kerala. Regarding political empowerment, after the implementation of Panchayati Raj in early 90s and the decentralisation of power in the local self-government department bringing a reservation for women first up to 33% and then to 50%, women empowerment has increased on a great sense. But, violence and sexual harassment against fisherwomen are on an increasing trend. Still they face several social and economic barriers. So gender specific strategies are to be initiated and implemented, like establishment of self-help groups, etc., thereby creating additional livelihood opportunities for them.With education, awareness, active participation and employment generation by implementing inter-disciplinary models through SHGs and welfare schemes, they can drive the development process in a faster pace. So, it should be a strong focus on involving and empowering women in particular because income earned by this group is more likely to benefit the entire household. Gender sensitive research helps in attaining the inclusive growth through finite strategies of development, so the sustainable goals can be met for uplifting the vulnerable groups in the context of aspects like climate change and development".(Pavithran.A.P, Sachin; Devi.D,Sarada, 2017).

So, altogether, for the betterment of the condition of the fishing communities, development of regional adaptation networks is a necessity. According Sunil Santha, "formal adaptation strategies are highly techno-centric, costly, and do not take into account the vulnerabilities of the fishing community. Instead, they have contributed to ecological, livelihood, and knowledge uncertainties. The adaptation strategies of the fishing community are a response to these uncertainties." So, evidences are to be generated, gathered and documented. Linkages between scienctific aspects, policies and practice should be strengthened. Establishment of the network between the members and identifying the location's priority needs helps in addressing the problems more systematically and efficiently.

## III. MAJOR HAZARDS THAT AFFECT THE COASTAL FISHING COMMUNITIES IN ERNAKULAM

1.Cyclone, which hinders the fishing activity for a definite period of time, even affecting the marine lives also. The recent occurance of the cyclone, Okhi along the Kerala coast is a relevant example of how the livelihood of the fishing community were affected.

2.Storm surges , which curbs the boats from going in the offshore areas, thus curbing the prospects of a better catch. Fishing is mainly dependent on seasons and a poor or delayed monsoon, which affects the indigenous and seasonal fishes and thereby, the seasonal harvests also.

3.Floods, can hamper the livelihoods of the fishing community, affecting the poor infrastructure and fishing activities.

4.Sea level rise, can cause the various outcomes of variation in currents and bottom pressure in the near shore regions, variation in tidal activities, changes in wave patterns, and so on.

5.Coastal erosion, is reported to affect about 23% of the shoreline along the Indian mainland. (Vivekanandan,2011)

6.Fish availability can change with respect to tabulations in the weather pattern and it manifests in the forms of changes in the migration and breeding seasons of fish varieties , or even endangering some of the fish varieties eventually.

## IV. MATERIALS AND METHODOLOGY

Selection of coastal villages Coastal villages from Ernakulam District for the study were selected based on different parameters viz., socio-economic factors, number of families below poverty line, job migration, infant mortality, adult-child ratio, average family size, gender ratio, literacy rate, dependence on fishing activities, craft and gear inventories, participation in cooperatives and ancillary activities. The study was conducted for a period of one year from May to November 2015 .

## V. SOCIO-ECONOMIC PROFILE

The socio economic profile collected include ages of the fishers, educational standards of the fishers , experience in fishing( years) and distance of houses from coastline (m). The study on the age distribution of respondents revealed that the majority of them belonged to the mid age group of 36 to 55 years.This was followed by older age group, i.e.; people belonging to over 55 years and finally the young age group. The younger group being in minority can probably be attributed to change from traditional fishing to other means of livelihood.

## VI. RESEARCH METHODOLOGY

Vulnerability studies are being conducted on an increasing basis, due to growing concerns and discussions regarding the various effects and implications of climate change as well as the socio-economic resources. So the various potential drivers that helpsin adding the frame to the vulnerability study of fishing community were to be considered.

Vulnerability to climate change is defined by IPCC (20007:883) as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, indicating climate variability and extremes" and is a "function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity".

The vulnerability indices were constructed using parameter, attribute, resilient indicator and score (PARS) methodology, a conceptual framework developed for assessing the climate change vulnerability of coastal livelihoods. PARS provides prioritisation and ranking of different impacts as perceived by the fishers and the frame work allows adequate distribution between fishing. The fishers were asked to rank between 1 – 5 indicating the severity of the vulnerability: 5 indicates very high, 4 - high, 3 - medium, 2 - low and 1- negligible/marginal. Each and every parameter will lead to different attributes and the attributes will lead to different statements or resilient indicators which will be based on different scores. The rank based quotient technique was used to analyse the scores and the ranks were in such a way the most affected attribute will get the highest ranking. PARS methodology was analysed using rank based quotient (RBQ) formula of Sabarathnam (1988).

The formula has the following form:

$$RankBasedQuotient = \sum_{i=1}^{} (\mathrm{Fi})(\mathrm{n} + 1 - \mathrm{i}) X \frac{100}{Nn},$$

where, Fi = number of farmers reporting a particular problem under ith rank, n = number of problems identified and N = number of fishers.This methodology is very much useful to find out which parameter or which attribute of the parameter is the most vulnerable factor of the area in terms of climate change.

## VII. RESULTS AND DISCUSSION

### 7.1. Analysis of Vulnerability Parameters

Table 7.1: Rank wise analysis of various vulnerability parameters

| Parameters | Chellanam | Rank | Cheriyakadavu | Rank | Kannamali | Rank | Composite data | Rank |
|---|---|---|---|---|---|---|---|---|
| Environmental | 60.23 | 2 | 59.31 | 1 | 58.30 | 3 | 59.28 | 2 |
| Fishery | 62.45 | 1 | 58.43 | 2 | 61.30 | 1 | 60.72 | 1 |
| Social | 57.43 | 4 | 57.50 | 3 | 60.40 | 2 | 58.43 | 3 |
| Economic | 58.32 | 3 | 53.43 | 5 | 59.45 | 4 | 57.06 | 4 |
| Development Drivers | 52.45 | 5 | 56.45 | 4 | 58.40 | 5 | 55.76 | 5 |

Source: Primary data

PARS methodology was applied in an effort to understand the indicator factors of coastal vulnerability in the selected fishing villages of Ernakulam district and scale up the impacts, adaptations and mitigation plans of coastal livelihoods to the district level. The application of PARS methodology in this study helped to assess impact of climate change on the five different parameters considered.

Among the three fishing villages studies, the analysis of environmental parameters showed that Chellanam was the most vulnerable area (60.23%) towards the climate change; followed by Cheriyakadavu (59.31%) and Kannamali (58.30%). While analysing fishery indicators also Chellanam was found to receive major part of the impact (62.45%), and Cheriyakadavu was the least affected with (58.43%) and Kannamali being 61.30% susceptible to the impact. When considering the third indicator, i.e., the social parameters, it was found that Kannamali faced 60.40% of impacts of the social indicators, and Cheriyakadavu and Chellanam remained somewhat similar with 57.50% and 57.43% respectively.The same pattern was seen upon analysing the impact of development drivers with Kannamali having 58.40% ,Cheriyakadavu with 56.45% and Chellanam having 52.45%. In the case of economic parameters, Kannamali had the most impact among the three fishing villages, with 59.45 %, followed by Chellanam (58.32%) and Cheriyakadavu (53.43).

Upon considering the composite data of all the three villages, it was found that the fishery indicators affected the villages the most with 60.72%. This was followed by environmental parameters (59.28%) and social parameters (58.43%). The villages were affected by economic indicators by 57.06% and lastly by development drivers by 55.76%. Several selected aspects were considered upon selecting the various indicators which were clubbed together under various parameters.

The study in the selected fisher households in all the three villages indicated that climate change has mostly impacted fishery based on the fishers' perception on different attributes followed by other attributes. In Chellanam fishing village , fishery parameters(62.45%) had severe impacts, which were followed by environmental impacts (60.23%) and economic impacts(58.32%); whereas in Kannamali, fishery attributes had the greatest impact (61.30%), which were followed by social impacts(60.40%) and economic attributes(59.45%).

The data on the composite villages indicated that on a wider level also, fishery is the most impacted parameter, owing to the heavy felt effects of the climate change followed by the effects and impacts of environmental and social parameters. Here, development drivers is the least impacted parameters as perceived by the fishers.

### 7.2. Fishers' perception on the causal factors of climate change

An analysis was carried out to assess the fishers' response to what could possibly be the causal factors for climate change. The perception of the fishers towards the casual factors of climate change indicated that temperature, sea level rise, ocean currents, landslides, urbanisation, cyclones, industrialization, habitat destruction, pollution and wind can be considered as the causative agents of climate change.

The potential causes for the various impacts can be related to anthropogenic (pollution and overexploitation) and climatic factors. Upon considering the views of the community level actors, both pollution and rising fishing pressure that leads to increased exploitation of the marine resources, are also considered as major stressors on fisheries resources. (Vivekanandan, 2011). The fishers responded that temperature (85.9%) followed by pollution (75.2%) and sea level rise (63.1%) as the significant causal factors for climate change.

## VII. CONCLUSION

The study indicated that fishers' response to climate changes was in consonance with real time changes in the environment, with regard to temperature rise, rate of pollution, the change in wind pattern as well other ocean parameters. It was also noted that the long term effects of climate change weren't felt much among the fisher household. The fishers could only realize immediate issues such as loss in fishing days and erratic monsoon resultant which in turn leads to economic losses. Relatively poor technology,

infrastructure, economical factors of cost and revenue, barriers and laws, along with the equity issues related to the accessibility , poor linkages and gender related social and economic barriers adds up the crisis. This can be effectively addressed through sustainable management andensuring equitable resource distribution, capacity building, promoting adaptive capacity, spreading awareness on various laws and schemes, establishment of institutions, taking measures to protect the environment and by emphasizing the gender sensitive strategies.

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