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Vulnerability Assessment of Coastal Fisher Households in Tamil Nadu, India: A Climate Change Perspective

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ABSTRACT

Climate change is predicted to have a wide range of impacts on fisheries and those who depend on them. Coastal vulnerability describes the exposure of the natural system and of coastal livelihoods towards exigencies. The climate change has multidimensional impacts on environment, fishery, social, economic and development drivers. The perception level of the primary stakeholders- leads to their proactive participation in disaster management plans. The present paper assessed the vulnerability of 400 fisher households in Ramanathapuram district of Tamil Nadu, India using PARS methodology - Parameter, Attribute, Resilient Indicator and Score. The methodology provides prioritization and ranking of the different impacts as perceived by the fishers on the different environment, fishery and socio economic parameters. The vulnerability indices were worked out for the fisher households. The fishers' perception revealed that fishery was most impacted followed by economic and environmental impacts. The study indicated that long term effects of climate change aren't realized/perceived impacted much among the fisher households. The fishers were more prone to loss in, fishing days due to erratic monsoon. The paper suggested the immediate need to improve the primary stakeholders awareness by involving them in disaster preparedness, management and mitigation planning and implementation process.

Key words: Coastal vulnerability, vulnerability index, PARS methodology, adaptation, mitigation

INTRODUCTION

Fisheries and aquaculture play significant roles for food security and income generation. Climate change is projected to impact generally across environments, societies and economies, including those in the fisheries and aquaculture sector. Globally some 43.5 million people work directly in the sector, of which over 90 per cent are small-scale fishers (FAO, 2005a) and indirectly nearly 200 million people are involved in secondary and tertiary sector (Cochrane et al. 2009). In India around 3.6 million people are involved in marine fisheries sector for their livelihood

Food and Agriculture Organization (FAO) reported that marine fisheries production was maximum in the 1980s and that over recent years, approximately half of fisheries have been exploited to their maximum capacity, one quarter overexploited, collapsed or in decline and only one quarter have had potential for increased production (Hilborn et al., 2003; FAO, 2007, 2005 b). 'Fisheries make a moderate contribution to Green House Gas emissions through fossil-fuel-based catching operations and transportation, which may be reduced with improved technology and management of stocks' (Daw et al., 2009). However, climate change is predicted to have a wide range of impacts on fisheries and those who depend on them. 'In general, there is limited observational information on climate change impacts on marine ecosystems. For example, only 0.1 per cent of the time series examined in the IPCC reports were marine' (Richardson and Poloczanska, 2008). There is much less knowledge on how the climate change impacts will be intervened by the socio-economic context of fisheries and how adaptation will proceed. To address this knowledge gap, the present study was aimed to assess the vulnerability indices in selected districts and villages of Tamil Nadu, state of India.

Tamil Nadu has a coastal length of 1076 km (13% of the country's coast line) 0.19 million sq.km of EEZ (9.4% of the India's EEZ) and a continental shelf of about 41,412 sq.km. and is one of the leading states in marine fish production. The marine fisheries potential of the state is estimated at 0.719 million tonnes. The State has fishermen population of 1.05 million of which 0.20 million fishermen are actively engaged in fishing from 608 marine fishing villages scattered along the 13 coastal

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districts namely Thiruvallur, Chennai, Kanchipuram, Villupuram, Cuddalore, Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari. In the inshore waters the fishery potential is exploited by 27,426 traditional crafts and 5,600 mechanized boats. The infrastructure facilities include 3 major fishing harbours, 5 medium fishing harbours and 363 fish landing centres. The marine fishing potential of Tamil Nadu is estimated at 0.72 million tonnes out of which 0.37 million tonnes comes from less than 50 m depth and 0.35 million tonnes from beyond 50 metre depth. Tamil Nadu contributes 10-12 per cent of the total marine fish production in India. The marine fish production for 2012-13 is 4.28 lakh tonnes. The export of marine products from the state during 2012-13 amounted to 77,791 metric tonnes valued at ₹ 2, 995 crore.

In Tamil Nadu, Ramanathapuram district is one of the important coastal districts, rich in marine resources. It has the coastal length of 236 kms starting from Sundarapandian Pattinam to Rochma Nagar comprising of Palk Strait and Gulf of Mannar.

METHODOLOGY

Selection of coastal district

The district was selected based on computation of an index which was developed by Patnaik and Narayan (2005). To assess the coastal district vulnerability selected parameters and attributes are Demography- number of villages, number of households, total population, literacy; occupation-Fulltime labourers, part-time and occasional, Infrastructure- Kutcha houses, educational institutions, number of hospitals/ dispensaries, number of banks, number of fishermen co-operative societies, number of community centers; Climate components- temperature, sea level, salinity, wind velocity, rainfall; Fishery components- mechanised, motorised, non-motorized, number of active fishermen. The data for the above attributes were taken from marine fisheries census 2010 published by Central Marine Fisheries Research Institute (CMFRI). The vulnerability indices for the coastal district were derived using formula:

VI=Vulnerability index $= VI = \left[\sum_{i=1}^{n} (AI_i)^{\alpha}\right]^{1/\alpha} \Big/ n$

(AI) is the average index for each source of vulnerability, n is the number of source of vulnerability and α=n.

The Intergovernmental Panel on Climate Change defined of vulnerability as "a function of the character, magnitude, and rate of climatic variation to which a system is exposed, its sensitivity, and its adaptive capacity." (McCarthy et al., 2001).

Selection of coastal villages

There are total seven taluks in Ramanathapuram district, out of which four taluks are under coastal area namely Kadaladi, Ramanathapuarm, Rameswaram and Thiruvadanai extending from Sundarapandian Pattinam in North to Rochma nagar in South direction. The district comprises of 178 coastal fishing villages. There are total 23 coastal villages in Kadaladi taluk, 101 coastal villages in Ramanathapuram taluk, 31 coastal villages in Rameswaram taluk and 23 coastal villages in Thiruvadanai taluk. The selection of different villages of Ramanathapuram district was carried out based on the indices derived using the different social and economic parameters like, number of fishermen families with due weightage given to traditional fishermen families, BPL families, adult- child ratio, average family size, sex ratio, literacy rate, full time fisher men, part time fishermen, craft and gear used and number, cooperatives and ancillary activities based.

Construction of coastal vulnerability indices

The vulnerability indices for the coastal livelihoods were developed. In order to construct vulnerability indices, the samples were drawn proportionate to the distribution of households on the coastline. The data were collected across the villages using a pretested well-structured interview schedule. The data were collected on general particulars including family details, education, asset particulars, savings, farming system, livestock and mostly on climate change awareness, perception and its causal factors. The level of awareness, preparedness and mitigation, alternate avocation options, community involvement and mobilization and level of governmental support and requirements were also included.

The vulnerability indices were constructed using PARS methodology, a conceptual framework was developed for assessing the climate change vulnerability of coastal livelihoods. PARS-Parameter, Attribute, Resilient indicator and Score, the methodology provides prioritization and ranking of different impacts as perceived by the fishers. The framework allows adequate distribution between fishing. The fishers were asked to rank between 1 – 5 indicating the severity of the vulnerability,where 5 indicates very high, 4- high, 3-medium, 2- low and 1- negligible/marginal. So each and every parameter would lead to different attributes and the attributes will lead to different statements or resilient indicators which will be based upon different scores. The rank based quotient technique was used to analyse the

scores and the ranks were given in a way the most affected attribute will get the highest ranking. PARS methodology was analysed using Rank Based Quotient (RBQ) formula (Sabarathnam, 1988) which is given below.

The values were measured for each statement and the analysis was done for 125 statements which are related to the climate change.

$$\text{Rank Based Quotient} = \sum_{i=1}^{n} (Fi)(n+1-i)X\frac{100}{Nn}$$

Where, Fi= frequency of respondents for the ith rank

N= total number of respondents

n= total number of ranks / factors

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 on a first hand analysis itself. This kind of bottom up approach would help the climatologists and policy makers to implement climate adaptation plans for the district, state and finally to the country.

RESULTS AND DISCUSSION

Selection of coastal district

The coastal district vulnerability index was derived for different coastal districts of Tamil Nadu based on the Patnaik and Narayan model. The selection of the district was based on assessment of coastal district vulnerability index estimated for different coastal districts (Table 1) of Tamil Nadu. Based on these parameters vulnerability index was analyzed and Ramanathapuram had the highest vulnerability followed by Kanyakumari and Nagapattinam.

Table 1: Vulnerability assessment of coastal districts in Tamil Nadu

District	Demography	Occupation	Infrastructure	Fishery	Climate	VI
Thiruvallur	0.2071	0.0887	0.8216	0.2931	0.6621	0.1744
Chennai	0.2745	0.2113	0.7114	0.3314	0.7705	0.1712
Kanchipuram	0.3643	0.1453	0.6456	0.3689	0.6674	0.1525
Villupuram	0.2898	0.0300	0.7827	0.3537	0.7179	0.1736
Cuddalore	0.3859	0.1663	0.6645	0.3998	0.7370	0.1638
Nagapattinam	**0.5116**	**0.3279**	**0.5247**	**0.444**	**0.9200**	**0.1891**
Thiruvarur	0.0059	0.0630	0.8438	0.2500	0.7671	0.1859
Thanjavur	0.2410	0.0679	0.7651	0.3062	0.6751	0.1670
Pudukottai	0.3059	0.0765	0.7384	0.3440	0.6228	0.1593
Ramanathapuram	**0.9062**	**0.9734**	**0.1925**	**0.4454**	**0.6191**	**0.2195**
Tuticorin	0.4336	0.3299	0.5691	0.3120	0.4217	0.1249
Tirunelveli	0.2305	0.1014	0.8105	0.2874	0.1759	0.1624
Kanyakumari	**0.6885**	**0.9533**	**0.3401**	**0.5753**	**0.5588**	**0.2025**

For the present study Ramanathapuram district (Fig 1) was selected since it showed highest vulnerability. Some of the changes observed in Ramanathapuram district due to climate change are depicted in Table 2.

Fig 1. Map showing the study area

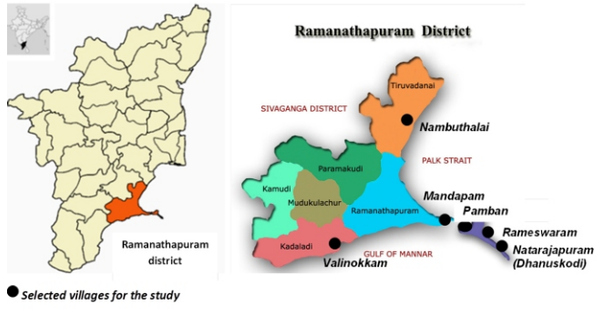

Table 2: Climate change in Ramanathapuram district of Tamil Nadu - Some Observations

	Changes observed in Ramanathapuram district of Tamil Nadu
Precipitation (Rainfall)	Compared to 20 years before, rainfall level and quantity is less. After Tsunami in 2004, the rainfall is erratic.
Temperature	Compared to 20 years before, the temperature is very high due to less rainfall
Extreme Weather Events	Due to sea level rise, sea erosion is occurring and the land area is occupied by the sea. During cyclone, the sea erosion is more.
Cyclones	Cyclone effect is less, but roughness of the sea is more
Drought	During the cyclone at 1964, severe drought occurred. Due to ground water depletion, drinking water availability is very less.
Heat waves	Compared to 20 years before, the heat waves is more
Shoreline changes	• At Chinnapalam, Ramanathapuram district of Tamil Nadu, before 20 years the seashore distance from the village based on the information provided by the local fishermen was 130 m, whereas now it is only 15 m. At Pamban (Light House), Ramanathapuram district of Tamil Nadu before 20 years the seashore distance from the village based on the information provided by the local fishermen was 110 m, whereas now it is only three metres. • At Mundraiyar Chatiram, Ramanathapuram district of Tamil Nadu before 25 years the seashore distance from the land based on the information provided by the local fishermen was 115 m, whereas now it is only 15 metres. • Based on the information provided by the local fishermen at Arichal Munai of Danuskodi where Gulf of Mannar and Palk Bay meets, in comparison to 20 years the seashore intruded the land by 65 metres.
Near shore fishing has drastically declined	Most of the sample households have revealed that near shore fishing has drastically decreased and they have to go for long distance for fishing.
Size of the fish has decreased	Large number of sample households have observed that the fish sizes have been decreased in recent years
Several species have declined severely	More number of fishers expressed that more fish varieties have been declined severely. The varieties are: Uluvai (Greater Lizard), Mandai Keeluthi (Giant Cat Fish), Kudipu (False Trevally), Madanam, Kutha, White Shrimp, Kathalai (Bearded Croacker), Ulluku, Vazhvadi Thirrukai (Spotted Eagle Ray), Karu vavval (Black Pomfret), Killathi, Paravai Mural (flying fish), Kallinga Mural,(Half beaked hemirhampus Basanthi, Karu Mural, Kellal,(bat fish), Sengani (sand bass), Kannadi parai, Kattyan and nettaiyan seela, Kombu sura, Yannai thirukkai
Several species which was caught before is not found now	Vela (saw fish), Pal uluvai (shovel nose ray), Vendra, Sambakala, Kakaullam, Sevaullam, Janesa, Vatha parai, poovazhi, Kola, Thangapappa, Kalaku sura, Seenikondan, Sellusaunni, Kallandan eral, Annamalai kathalai, Sigappukathallai, Veetupuci, Pulli eral, Karkadi eral, Vellai kelluthi, Kakka kelluthi.

Selection of coastal villages

The vulnerability index calculated for each coastal village and highly vulnerable villages were mentioned in Table 3. Based on the indices six villages were identified from the four taluks namely Mandapam, Rameswaram,Valinokkam, Natarajapuram (Dhanuskodi) Pamban and Nambuthalai which exhibited vulnerability very high indices and a total of 400 fisher households were selected for the study based on proportionate random sampling method. PARS methodology was used to assess the vulnerability of coastal livelihoods.

Table 3: Highly vulnerable fishing villages in Ramanathapuram district of Tamil Nadu

Taluk -I		Taluk -II		Taluk -III		Taluk -IV	
Kadaladi (0.1922)		**Ramanathapuram (0.2187)**		**Rameswaram (0.2201)**		**Thiruvadanai (0.2120)**	
Valinokkam	**0.2765**	Atangarai	0.2012	Olaikuda	0.1168	Morpanai	0.2532
Narippaiyur South	0.2629	Devipattinam South	0.1554	Soosaiyappar Pattinam	0.1310	Mullimunai	0.2345
Chinna Ervadi	0.1743	Irumani	0.1004	**Rameswaram**	**0.4011**	**Nambuthalai**	**0.2683**
Vellapatti	0.1495	**Mandapam**	**0.5901**	**Pamban**	**0.2684**	Puthukudi	0.1053
Sadaimunian Valasai	0.1552	Pudumadam	0.1428	**Natarajapuram (Dhanuskodi)**	**0.2699**	Thirupalaikudi	0.2484
Rochma Nagar	0.1348	Vedalai	0.1220	Victoryar Nagar	0.1329	Thondi	0.1625

Fishers' perception on the effect of climate change

PARS methodology was applied in an effort to understand the indicator factors of coastal vulnerability in the selected fishing villages of Ramanathapuram district. The application of PARS methodology in this study helped to assess impact of climate change on the five different parameters considered. The study based on fishers' perception on different attributes in the selected fisher households in all the six villages indicated that climate change has mostly impacted fishery followed by economic and environmental factors in Ramanathapuram district. Development drivers is the least impacted parameters as perceived by the fishers (Fig. 2).

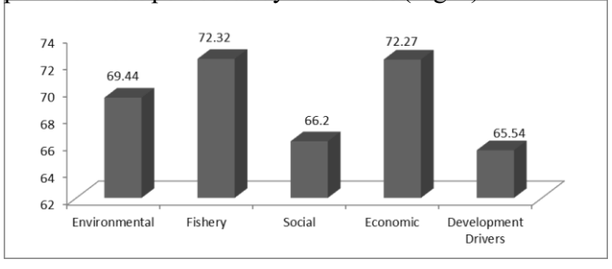

Fig. 2 Climate parameter assessment for combined six villages in Ramanathapuram district

Attribute analysis for the fishing villages

The attribute analysis was done to delineate the different resilient indicators impacting the response / perception to climate change among the fisher households. The attribute analysis of different parameter indicated that the fishery was impacted mostly by species composition and catch. The attributes loss in fishery inventory and aquaculture followed the species composition and catch attributes. The analysis on the resilient indicator to this attribute indicated that fish catch has decreased drastically over the years and effort has increased fairly, the fishing ground has changed or fishes are not available from the areas where they were abundant once, the by-catch and landing of juveniles has increased highly over the years. According to fishers' coastal fishes have migrated to open sea and there is a shift in spawning season of major fishes along the coast due to climate change. There is also significant shift in fishing season. Due to extreme weather events there is considerable damage to craft and gear in recent years. In Ramanathapuram district, seaweed farming is adopted by more than 1000 fishermen families. In last ten years, occasionally in some seasons the entire crop was destroyed due to high temperature and cyclone. Hence, some fishers' perceived that climate change may significantly affect the aquaculture (Fig. 3). Seaweeds provide shelter to a variety of organisms and enhance biodiversity. They absorb CO2 and reduce global warming (Israel *et al.,* 2010). They are also efficient in controlling organic pollution including heavy metals in the in shore waters. Thus, seaweed cultivation is an eco-friendly and sustainable source of income to the coastal poor.

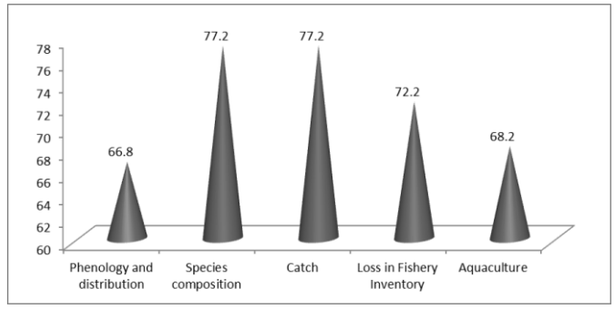

Fig. 3 Attribute analysis of climate change impacts on fishery

According to fishers' perception, economic attributes were impacted next to fishery in the context of climate change where, cost of fishing was the most limiting factor followed by income effect and loss in fishing days. This finding derived support from Hsieh *et al.,* (2006) who found overfishing in general has reduced revenues and economic efficiency. Cost of fishing has increased on an account of changed fishing ground and increased fuel cost. This finding derives support from FAO (2007) which reported that 'the doubling of the diesel price led to a doubling of the proportion of fishers' revenue that they

spent on fuel and rendered many individual fishing operations unprofitable'. The income effect has impacted due to decreased level of income, increase in cost of living and seasonality in employment combined with minimal alternate avocations. The fishers' perception is that there is a drastic reduction of fishery resources in the last ten years. The reasons for drastic reduction were increase in the number of boats, unregulated fishing practice and use of increased horse power engine in boats. All these reasons resulted in increased cost of fishing. Livestock and crops are the least impacted attribute. (Figure. 4)

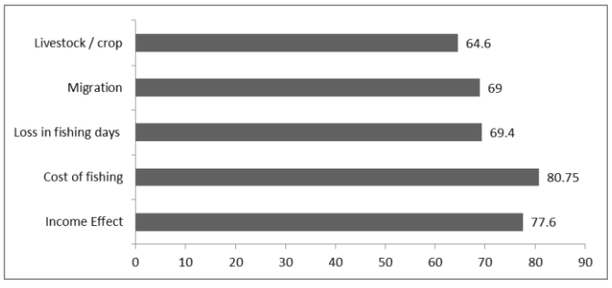

Fig. 4 Attribute analysis of climate change impacts on economy

Based on fishers' perception it was found that the third most affected factor due to climate change is environment. Among the parameters in the environment, the most significant factors' were sea level rise, sea water inundation and monsoonal fluctuation. Analysis of the statements of attribute revealed that there is substantial increase in sea level and coastal erosion in the fishing villages of Ramanathapuram which impacted fishing and allied activities of fishermen. This finding was consistent with the report of Allison *et al.,* (2005) who identified potential indirect ecological impacts on fisheries. The respondents also perceived that there is substantial decrease in rainy days over the years and erratic monsoon was noticed and freshwater sources were seriously affected and groundwater consumption has become difficult consequent to seawater inundation (Figure. 5).

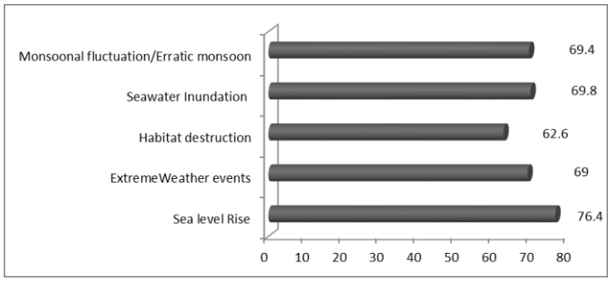

Fig. 5 Attribute analysis of climate change impacts on environment

The perception on the social factors impacting climate change in the fisher households was conceived at a low level. Infrastructure sensitivity is the highly impacted attribute followed by social participation and community orientation. The least impacted attribute is social standards. Infrastructure sensitivity is highly due prone to disaster dwellings. Social participation is impacted due to negligible training programmes, minimal sharing of technical knowledge, low awareness level is and decreasing. social participation among fishers Mobilization of community groups is very rare and community based grass root planning are lacking. (Figure. 6)

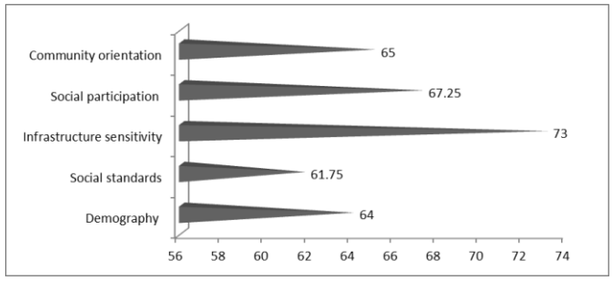

Fig. 6 Attribute analysis of climate change impacts on social factors

The study found that the perception on the development drivers impacting climate change in the fisher households was conceived at a low level. The attribute on anthropogenic drivers ranked more followed by policy support drivers. ICT enabled drivers and productivity enhancement drivers are least impacted. Statement wise analysis revealed that anthropogenic drivers is mostly impacted since coastal tourism and related activities are increased with use of plastic as well as residential area development of and a development activity doesn't care about sustainability issues (Figure. 7).

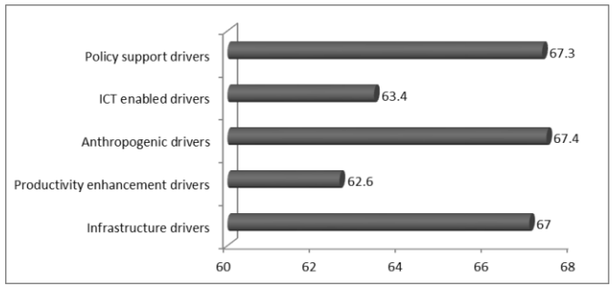

Fig. 7 Attribute analysis of climate change impacts on development drivers

The study clearly indicates that fishers perceive that the fishery, economic and environment parameters are of importance in the climate change adaptation and mitigation plan. The level of awareness is moderate to

low which indicate that the fishers couldn't correlate environmental changes consequent to climate change to their livelihood. The fishers were prone to loss in fishing days and erratic monsoon. There is need to improve on the awareness of the fishers knowledge to climate change by involving them in the disaster preparedness and planning process.

It is also suggested that the fisheries governance has to take account of socio-economic attributes, uncertainty and sustainability and to address over capacity and overfishing. Approaches such as co-management or participatory approaches can address the uncertainty and the knowledge and commitment of fishers on various areas can offer the best hopes for resilient fisheries. The process of fisheries and their associated communities adapting to climate change is facilitated and constrained by various social factors and involves value-based decisions and trade-offs. Now there is also a need for adaptive governance as well as integration of fisheries with available alternate avocations. The alternative avocations available across the different fishing villages need to be strengthened in order to negate the different risks and uncertainties of climate change and in ensuring a climate change informed fishers in the future. Thus a bottom up approach involving the primary stakeholders along with the community will adequately position them to climate change adaptation and mitigation by augmenting their traditional knowledge.

There is a growing awareness of the importance of understanding human aspects of fisheries and focusing on fisheries governance rather than purely management. Much more attention is now being paid to incentives created by management measures and institutional arrangements around fisheries, including the incorporation of local fishers and their knowledge through co-management and community-based management initiatives (Jentoft, 2006; Hilborn, 2003). This trend has been accompanied by a greater awareness of the importance of taking account of ecosystems within which fisheries are embedded. Both the involvement of stakeholders and the need to consider the wider ecosystem are incorporated in the Ecosystem Approach to Fisheries (FAO, 2003).

CONCLUSION

Climate change is predicted to have a wide range of impacts on fisheries and those who depend on them. The present study was aimed to assess the vulnerability indices on five parameters namely fishery, environment, economic, social and development drivers across the selected fishing villages of Ramanathapuram district of Tamil Nadu. The study revealed that fishery is the most impacted parameter as a result of climate change followed by economic and environmental impacts. The study clearly indicates that the long term effects of climate change aren't impacted much among the fisher household. Fishers perceive that the fishery and economic parameters are of importance in the climate change adaptation and mitigation plan. The fishers were prone to loss in fishing days and erratic monsoon. There is need to improve on the awareness of the fishers' knowledge to climate change by involving them in the disaster preparedness and planning process and in ensuring a climate change informed fishers in the future.

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