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PROOF RESEARCH PAPER

Vulnerability of Coastal Fisher Households to Climate Change: A Case Study from Gujarat, India

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Abstract

The impacts of climate change are invariably seen on agriculture, aquatic ecosystem, energy, and economics. The fishery sector on which livelihood of world's 36 million fishers depends is also not untouched but a little attention has been given to study the vulnerability of fisherfolk population to climate change programs. Therefore, the present study was envisaged to assess the vulnerability of fishers to the climate change in Junagadh district of Gujarat, India. The vulnerability of 1500 fisher household was assessed using PARS (parameter, attribute, resilient indicator, score) methodology, in four coastal villages namely Old light house, Bhidiya, Navabunder and Rajpara in Junagadh district. Five parameters viz., fishery, economy, social, environmental and development drivers have been assessed as indicators of sensitivity, exposure and adaptive capacity. 'Economy' was found to be the most impacted parameter consequent to climate change followed by the 'social' and 'environmental' parameters. The results obtained reflect low adaptive capacity of fishers that could be attributed to lack of awareness, preparation, and mitigation option. Thus, the finding of the study could be used as a vital input while developing the policy and suitable action plan to combat the impacts of climate change minimizing the risk to fisheries sector.

Keywords: Marine Fisheries, Vulnerability Index, PARS, Coastal livelihood, North west coast India.

Introduction

Climate change or global warming, the highly debated global phenomenon is an important area of research in the recent days. The increased incidences of loss of crops due to unprecedented droughts or increase in sea level rise due to excessive rainfall are few of the impacts believed to be generated from climate change (Gerald *et al*., 2009). Similarly, fisheries sector is not an exemption from the deleterious effects of climate change. The assessment of climate variability studies has reported changes in migration pattern of pelagic fishes such as tuna, anchovy and sardine fishery in Pacific Ocean (Chavez *et al.,* 2003), shift in recruitment regimes in tuna (Lehodey *et al.,* 2003) *Nemipterus japonicus* (Vivekanandan *et al.,* 2009) and expansion of inhabitant boundaries as shown by Indian mackerel and Oil sardine in tropical waters (Vivekanandan *et al.,* 2009a). Climate change not only influence the fishing directly by affecting various physiological process, developmental rates, reproduction, behavior and survival of individual but also affects indirectly by altering ecosystem, food availability, prey-predator relationship (Brander, 2010) . Studies have also been forecasted about the imminent future where the capture fisheries will get severely affected by climate change and thus affecting the national economics (Allison *et al.,* 2009). These findings provide insightful perceptive for vulnerability assessment of fisheries ecosystem which supports livelihood of over a half a billion people (Allison *et al.,* 2009 and FAO, 2010). The communities that depend on fisheries are more vulnerable to climate impacts such as cyclone, flood, droughts, sea level rise and temperature and rainfall variability (Sarch and Allison, 2000). These impacts increase the vulnerability of fishery-based livelihood (Perry *et al.,* 2009). Assessment has been made regionally and globally to delineate the impacts of climate change on country level (Harmeling, 2011). Haremling (2011) has evaluated the impacts of extreme weather events induced due to climatic variability on the lives, livelihood and socioeconomic attributes across 170 countries and concluded that six Asian countries namely Bangladesh, Myanmar, Vietnam, Philippines, Magnolia and Tajikistan as the most vulnerable countries. Examining the vulnerability of fishing communities will help in identifying and characterizing timely actions to be taken in order to combat with the negative impacts of climate change, and will help in successful implementation of various climate resilient policy by raising awareness, mitigation, and adaptation options.

India, the second largest producer of fish is contributing about 5.43% of the global fish production and ranks second in aquaculture, thus providing livelihood of 14 million people in the country (Das *et al.*, 2014). Impacts of climate change on Indian fisheries have been reported in the earlier studies (Vivekanandan, 2009, Vivekanandan, 2009a, Salagrama, 2012). However, vulnerability assessment at the local scale focusing the impact of climate change on small-scale fishers of the tropical region is lacking. Studies carried out by Das *et al.* (2014) assess the vulnerability of inland fisheries, whereas Patnaik and Narayanan (2005) and Shyam *et al*. (2014) assessed the vulnerability of coastal fishers.

Gujarat, with a coastline of 1600 km, ranks first in the marine fisheries production with an estimated landing of 7.12 lakh tons (CMFRI, 2015). With a dependency of 59889 families (Srinath *et al.* 2007) on fish and fishery based industries, coastal communities of Gujarat are more prone to suffer from the adverse effects of climate change. However, there has been no study until date, which deals with delineating the vulnerability of these coastal communities to climate change. Therefore, the present study was conducted in Gujarat to assess the important drivers of vulnerability for the fishery based livelihood in the coastal communities. Index based approached was adopted to address the socio-economic status of the communities in the purview of the impact of climate change. The impacts of climate change were evaluated based on the environmental, agricultural, demographical and infrastructural changes. The findings of the present study will provide necessary information in understanding the level of preparedness of the community to cope with the impact of climate change and also in developing appropriate mitigation strategy for fishermen welfare.

Materials and Methods

Study Site Selection and Data Collection

The present study was conducted using Gujarat as a model maritime state due to its significant contribution in the fisheries related activities. Gujarat with its longest coastline of about 1600 km and broadest continental self area of 1, 64,000 sq. km in India is also considered as one of the important centre for fisheries related activities in the entire north-western Arabain sea. Recently, Gujarat is the highest marine fish producing state of India and contributes nearly 0.7 million tonnes fish catch annually (CMFRI 2014 and 2015). Since it was extremely time intensive, expensive and cumbersome to carry out the survey in entire state a two stage sub-sampling protocol was followed in which 12 coastal maritime districts were evaluated at the first stage to find out the most vulnerable district. After the finalization of the coastal district, all the coastal villages in the district were evaluated to select a subsample of four coastal villages for the detail study.

Selection of candidate coastal district and villages were carried out by computing the vulnerability index developed by Patnaik and Narayanan (2005). In this method, the possible sources of vulnerability for each of the 12 coastal districts in Gujarat were identified followed by identification of sub-indicators for each source of vulnerability. Average Index (AI) for each source of vulnerability was calculated and then overall vulnerability index (VI) was computed for each of the districts. The district with highest score was selected for the subsampling of coastal villages. The method was repeated for all the coastal villages in the selected district to finalize the four most vulnerable coastal villages.

In the present study, four different parameter i.e., (1) demography, (2) occupation, (3) infrastructure and (4) fishery components were taken into consideration as the sources of vulnerability for the identification of most vulnerable coastal district. The parameters used as sub-indicators for each source of vulnerability are shown in Figure 1. Selection of different coastal villages from the identified district was carried out by constructing the vulnerability index of each village using different parameters as the sources of vulnerability such as socio-economic parameters, numbers of families below poverty line, adult-child ratio, average family size, gender ratio, literacy rate, dependency on fishing activities, craft and gear inventories and participation in cooperatives and ancillary activities. These parameters were obtained as secondary data from the Marine Fisheries Census (2010). The overall vulnerability index was computed using the following formulae

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

Where, VI = vulnerability index,
AI = average index for each source of vulnerability,
n = number of source of vulnerability and α=n

Definition of Scope and Goal of the Study

Designing of Coastal Livelihood Vulnerability Index

The vulnerability index for the selected coastal livelihood was constructed by combining the indices for exposure, sensitivity and adaptive capacity. As described in the previous studies (Vas *et al.*, 2009, Allison *et al.*, 2009, NPCC 2008-09, Allison *et al.*, 2005, Das *et al.*, 2014) the exposure was defined as degree of climate stress upon coastal livelihood due to the long-term changes in climate condition (IPCC, 2001). The parameter used to assess the level of exposure of the system was the environment related anomalies, which were assessed using five attributes (Figure 2). Sensitivity was defined as the degree to which the coastal livelihoods would be affected due to the impact of climate change (IPCC, 2001). The sensitivity of the system was measured using fishery and social parameters. The attribute selected to represent the sensitivity due to fishery and social related issues were shown in Figure 2. The adaptive capacity of the fishery livelihoods is measured the potential of such livelihoods to adjust to climate change or to moderate the potential damage or to take advantage of opportunity or to cope with the consequences (Smit and Pilifosova, 2001). For assessment of adaptive capacity of the coastal livelihoods, economy and development drivers that

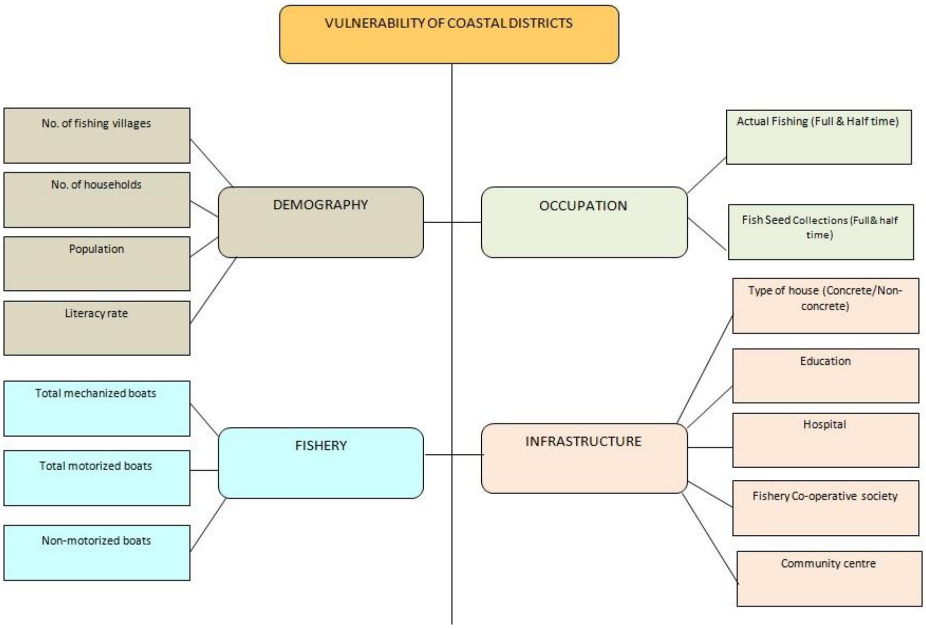

Figure 1. Framework for assessing the vulnerability of coastal districts.

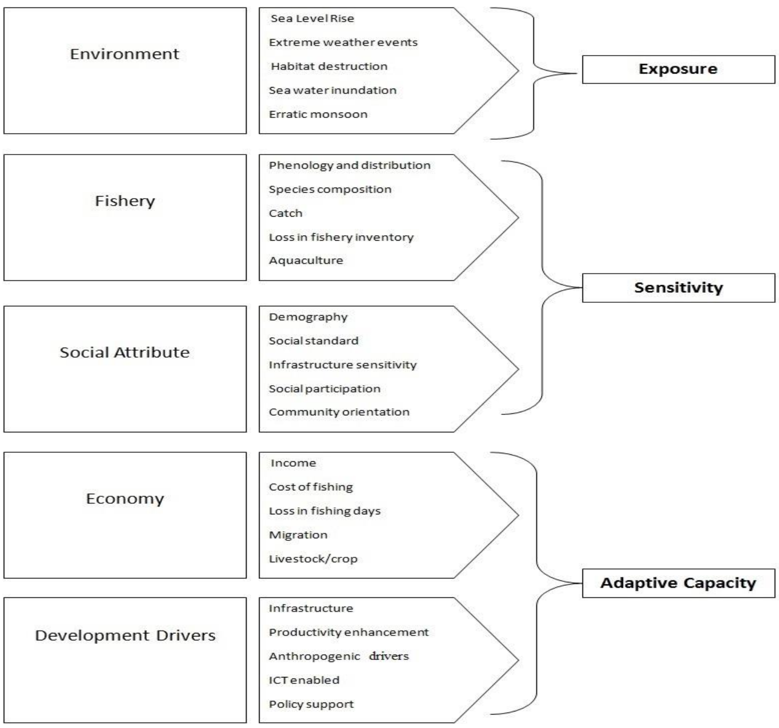

Figure 2. Framework for construction of vulnerability index including parameter and attribute used in PARS methodology.

influence the fisheries through a range of direct and indirect pathways were considered. The attributes selected to measure economy adaptive capacity and development drivers are shown in Figure 2.

All the above mentioned attributes were used to construct a complex coastal livelihood vulnerability index by following the Relative Weighted Score Index (RWSI) using PARS (Parameter, Attribute, Resilient indicator and Score) methodology (Shyam *et al.,* 2011 and 2014). PARS methodology is a conceptual framework developed for assessing the climate change variability of coastal livelihoods. The PARS methodology provides prioritization and ranking of different parameters as perceived by the fishers. Five resilient indicators were used for each of the attributes, which constituted 125 queries, which were scored by the non-repetitive random interviewing of 1500 fishermen using a set of standard pre-tested, pre-structured questionnaire. The fishers were asked to rank each of the resilient indicator from 1 to 5 indicating the severity with 5 being very high, 4- high, 3- medium, 2- low and 1- negligible/marginal based on their perception. The results obtained through the PARS methodology was analyzed using RBQ formula (Sabarathnam 1998). The analysis was done for 125 statements using the value measured for each statement.

$$RWSI = \frac{\sum_{n=1}^{\infty}(\mathrm{F_i} \times \mathrm{r_i})}{Nn} \times 100$$

Where, F_i: Frequency of fishers for the i^{th} rank of statements

r_i: Assigned rank

N: No. of fisher

N: No. of problems identified

Results

The initial objective of the study was the identification of most vulnerable coastal district. The vulnerability index obtained for different coastal districts using method described by Patnaik and Narayanan (2005) is shown in Table-1. The highest value was obtained for Junagadh district and hence was selected for the study. The second objective of the study was the identification of coastal villages from the Junagadh district, which have higher vulnerability to the impact of climate change. Junagad district comprises of six taluka having 16 fish landing center spread across 27 fishing villages with a total population 92,076 fishermen. The highest vulnerability index was obtained for Bhidiya fishing village followed by Old lighthouse, Navabunder, Rajpara villages and hence were selected as candidate villages for the present study (Table 2, Figure 3).

Based on the analysis of five parameters across four selected villages, economy was found to be most impacted parameter due to the climate change. Since economy of the fishery sector in the area is an important parameter used to calculate the adaptive capacity of the sector, it indicates that the system is very much susceptible to the possible impacts of climate change. The economy was followed by social parameter, which determines the sensitivity of the area. The degree of exposure of the system to the climate change, that was measured by environment parameter in the present study ranked third among the impacted parameters (Figure 4). However, little variation can be seen at individual village level, thus pointing the fact that each village was susceptible to climatic changes at different degree. The study highlights that the most significant impact of climate change at Old light house, Rajpara and Navabunder was found to be on the economic factor which comprised of attributes like increase in the cost of fuel, crafts and gears and loss due to spoilage and expansion in fishing area. On the other hand, environment formed the most impacted parameter as a result of climate change at Bhidiya, which could be attributed to the high level of pollution caused by factories in the Gujarat Industrial Development Corporation (GIDC) Special Economic Zone (SEZ) in Veraval and transport vessels ferrying goods. The second most important attribute impacted by the climate change in all the villages of study was 'Social parameter' as about 37% of the population was found to be living in areas which are prone to disaster and with minimal healthcare and sanitation facilities (Figure 4).

Table 1. Vulnerability index of coastal districts of Gujarat

District	Demography	Infrastructure	Occupation	Fishery	VI
Valsad	0.38	0.45	0.34	0.17	0.13
Navasari	0.24	0.27	0.26	0.05	0.08
Surat	0.17	0.15	0.27	0.01	0.05
Bharuch	0.16	0.25	0.50	0.03	0.13
Anand	0.01	0.89	0.25	0.00	0.22
Bhavanagar	0.14	0.36	0.15	0.01	0.09
Amerli	0.14	0.54	0.12	0.04	0.13
Junagadh	0.60	1.06	0.62	1.00	0.32
Porbander	0.21	0.47	0.47	0.31	0.14
Jamnagar	0.36	0.69	0.37	0.17	0.18
Rajkot	0.32	0.23	0.21	0.04	0.09
Kutch	0.37	0.70	0.49	0.09	0.19

Table 2. Vulnerability of coastal villages of Junagadh District

Taluk		Village	VI	Taluk		Village	VI	Taluk		Village	VI
Taluk 1(0.24)	Kodinar	Kaj	0.26	Taluk 4 (0.22)	Sutrapada	Dhamlej	0.22	Taluk 6 (0.25)	Una	Dhandi	0.19
		Kotada	0.91			Hirakot Bunder	0.17			Delwada	0.18
		Madhwad	0.26			Sutrapada	0.31			Kalapan	0.22
		Muldwarka	0.29			Vadaodara Bara	0.18			Khada	0.21
		Velan	0.22	Taluk 5 (0.37)	Veraval	Jaleshwar	0.25			Kob	0.28
Taluk 2 (0.22)	Maliyahatina	Chorwad Bunder	0.22			Veraval Bhidiya	0.31			Manekpur	0.21
Taluk 3(0.31)	Mangrol	Mangrol Bunder	0.49			Veraval old light house	0.54			Navabunder	0.32
		Mangrol Bara	0.18							Paldi	0.28
		Shil Bunder	0.24							Rajpara	0.39
										Seemar	0.22
										Senjaliya	0.24

* Vulnerability Index (VI)

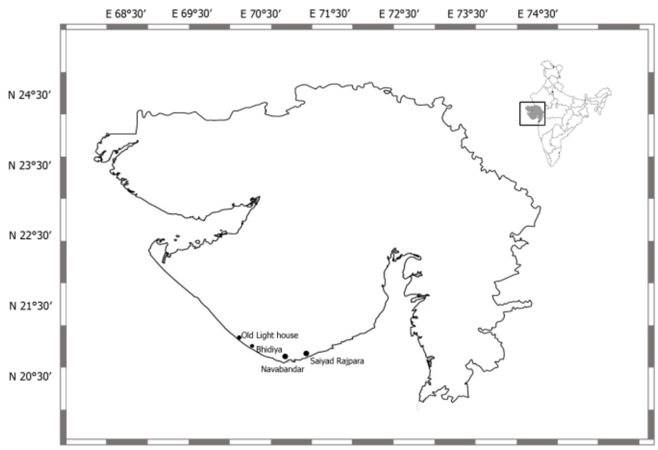

Figure 3. Study area depicting the vulnerable coastal villages along the Gujarat Coast.

Environment as an Indicator of Exposure

The study indicates that the changes in the environment are drastically impacting economy and livelihood capacity of fishermen. The erratic monsoon prevalent in the recent days was perceived as the most important consequence of the climate change. The respondents also admitted about the increase in sea level and frequent occurrence of extreme weather events such as cyclone, which cause considerable damages to the crafts and gears. It was observed that there is increased incidence of breach of high tide line by the waves causing inundation by seawater in the coastal areas bringing hardships to the native local settlements. The minimum distance between residential area and the coastline varied from 330 m at Bhidiya to about 925 m at Navabunder which indicates the higher vulnerability of these villages to inundation due to sea level rise. It was also noticed from the fishermen response that there has been a decline in mangrove, seagrass bed as well as coral reef ecosystem (Figure 5)

Fishery and Social Parameter as an Indicator of

Sensitivity

The attribute analysis on fishery revealed a considerable decline in the fish catch over the period of time followed by changes in phenology and distribution. A continuous shift in fishing ground of major fishery resources was also noticed which confirms a change in the distribution pattern of fish species. However, neither any emergence of new fishery of considerable significance nor any disappearance of the existing major fishery was noticed during the survey. It was also perceived that there has been a considerable shift in the species composition of fish (Figure 6)

Social standard was found to be the most impacted attribute designed to evaluate the sensitivity of the society to the adverse impact of climate change. A dearth of drinking water, proper sanitation and health care facility was apparent in the studied fishermen society. The second most impacted attribute was infrastructure sensitivity and was found that most of the fishermen in the present study were living in disaster prone areas with poor access to communication, waste management and with poorer infrastructure for disaster management. Demography and social participation were found to be equally

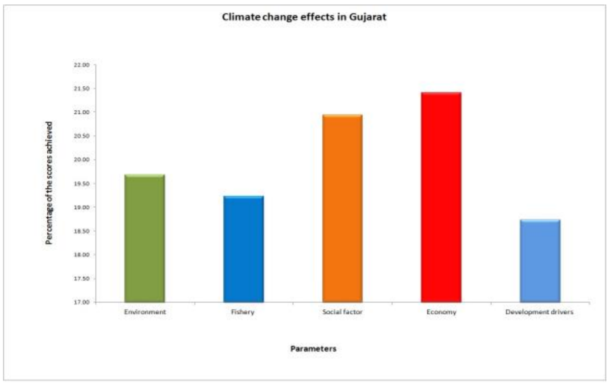

Figure 4. Impact of climate change on various indicators of fisheries in Gujarat.

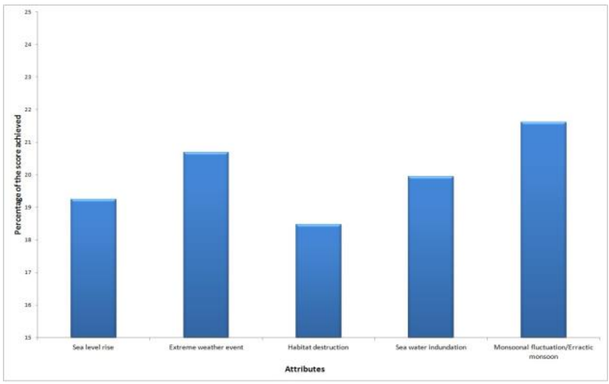

Figure 5. Attribute analysis of climate change impact on environment.

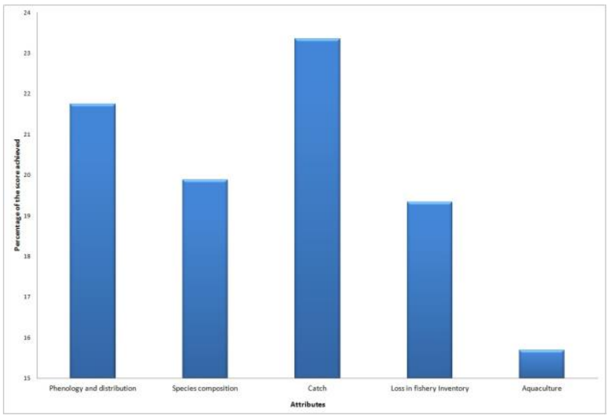

Figure 6. Attribute analysis of climate change impact on fishery.

contributing to the sensitivity of the societies towards the impact of climate change. Orientation of the community was evaluated as the list impacted attribute for sensitivity study (Figure 7)

Economy and Development Drivers as an Indicator of Adaptive Capacity

In the present study, adaptive capacity that measures the potential of fishers to cope with the climate change was found to be the most impacted parameters. Financial capital i.e. income was found to one of the significant indicator of adaptability. The input cost of fishing was found to be increasing coupled with decrease in number of fishing days, which are effectively diminishing the revenue from the fishing and thus decreasing its adaptive capacity. The third worst impacted attribute was negative income effect followed by migration of fishers to other livelihood options. However, livestock and crop was found to be least impacted by climate change in these villages (Figure 8)

Nevertheless, the development drivers, though at low level, were also perceived as one of the factors intensifying the impact of climate change on the fisher household. The anthropogenic drivers that include costal tourism and increased use of plastic ranked the highest followed by productivity enhancement and infrastructure driver. As per fishers perception there was considerable lack of information and communication technology (ICT) enabled drivers, policy support drivers, as well as planning process for the relief and rehabilitation by the administration, which is increasing their vulnerability to natural calamity (Figure 9).

Discussion

The present study assessed the vulnerability of fishery-based livelihoods to the climate variability and changes using locally relevant indicators of exposure, sensitivity, and adaptive capacity. The study revealed that the fishery based livelihoods of Junagadh district has the highest vulnerability among the coastal districts of Gujarat. Assessment of the vulnerability indices across the fishing villages of the district revealed that economy forms the most vulnerable parameter due to the consequence of climate change followed by the social and environmental parameters.

The unusual prolonging of the windy days of monsoon as well as their unseasonal occurrence is severely reducing the total active fishing days in a year. The months following the monsoon was considered to be crucial as it was found to be the peak fish landing period and any aberrations in weather

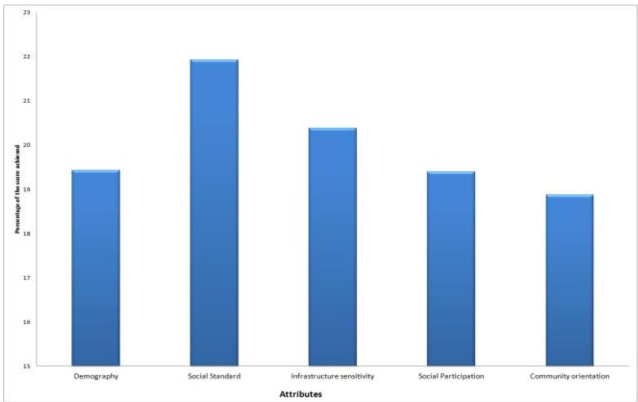

Figure 7. Attribute analysis of climate change impact on social parameter.

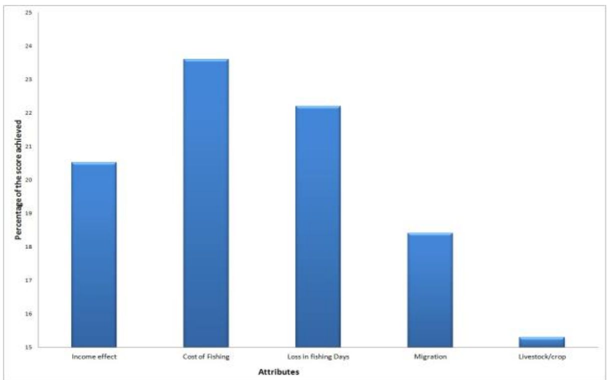

Figure 8. Attribute analysis of climate change impact on Economy.

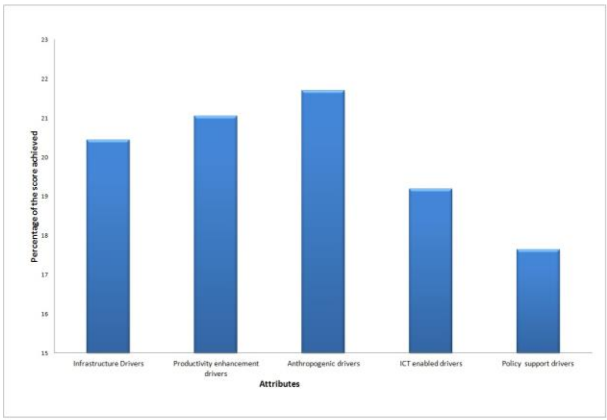

Figure 9. Attribute analysis of climate change impact on developmental drivers

such as occurrence of high speed winds or cyclonic weather during this season could adversely affect the income and job opportunities of fishermen. Similar results has been reported by Sano *et al.* (2011) where extreme erosion events and higher storms surges has been related with increase in sea level rise. All these events are significantly increasing economic loss and hence increasing the vulnerability of fisher folk. Since fishers dwell at immediate vicinity to sea shore, any increase in sea level will increase inundation of the available coastal areas which will consequently increase their exposure and vulnerability to the deleterious effect of climate change. Furthermore, the deterioration of fishery environments is damaging the sensitive habitats like mangroves, seagrass beds and coral reefs. Since, these sensitive habitats are considered as the nursery of the ecosystem this will adversely affect the recruitment of juveniles to the fishery and thereby increase the exposure of the fisher folks to the climate change. In an earlier study, Daw *et al*. (2009) has discussed the effects of climate change on large-scale marine fisheries that include damages to vessels and shore based infrastructure, along with reduction in employment opportunity and negative impact on market structure.

The shift in phenology, distribution and catch composition of fish species are primarily caused due to changes in environment and this depicts the degree of sensitivity of the sector to the possible deleterious impacts of climate change. Due to frequent anomalies in environmental variables such as sea surface temperature (SST) and precipitation, the phenology of fish is getting affected drastically. Because of which alteration in spawning season, decrease in size of maturity and decline in brooder biomass are much evident nowadays. Furthermore, coastal fishes and pelagic fishes, which were earlier occurring in inshore waters, are nowadays found more towards deeper sea. One interesting example cited during the present study was the huge catch of Indian mackerel by the multi-day trawlers. Due to changes in distribution pattern and environment, the species composition of catch is also changing. All these anomalies were also identified as the reasons responsible for the increase in by-catch landing, which has created a new market for fishmeal. Moreover, it was also revealed that the fishing of juveniles is increasing as a compensatory strategy to cope with the loss from diminishing targeted resources as well as total catch. However, this indiscriminate and unsustainable exploitation of juveniles can pose gravest threat of recruitment overfishing which can worsen the impact of climate change. Vivekanandan *et al.* (2010) discussed the deleterious effects of seawater warming, ocean acidification and sea level rise on fish phenology, distribution, and ecosystem, which in turns affects the food and livelihood security of coastal communities, their safety and efficacy of fishing operations on which sizeable section of population thrives. Similarly, negative impact of climate change on fish productivity, abundance and distribution has also been reported in previous studies (Cheung *et al.*, 2009, Badjeck *et al.*, 2010, Drinkwater *et al.*, 2010).

The social vulnerability with respect to climate change has been well discussed by Cutter *et al.* (2009). Social and political marginalization leaves many fishers with little capacity to adapt to climate impacts thus making them more vulnerable (World fish centre, 2007). The socio-economic standard of a society determine its ability to cope with adverse events and is mainly contributed by education facility, sanitation facility, access to drinking water and health care facility which are also considered as the critical factor for the social development. The sensitivity of the fisher folk increases due to their inadequate knowledge on climate change as a result of which they are not able to correlate influence of climatic changes on their livelihood. The finding of the present study indicates that though about 52% population is aware of climate change and its deleterious effects; most of them depend on traditional methods for their safety at sea. It has been found that fishers with higher level of education not only have better level of planning, access and understanding of early warning information but can also make better decision during natural shocks which decrease the sensitivity (Tesso *et al.*, 2012). Similarly, proximity of society to hazardous area, infrastructure for communication, waste and disaster management *etc.* improves the preparedness for unfavorable situation and thus increases its resistive capacity to the deleterious impacts of climate change. In the present study, these attributes were found to be severely compromised which is increasing the sensitivity of the society. The situation is getting worsen further due to other factors such as rise in population, gender disparity, nutritional scarcity coupled with decreased social interaction and poor technological knowledge, which are increasing the sensitivity of the fishermen societies. Furthermore, it was also noticed that the younger generation is changing its livelihood aspiration and nowadays it prefers to migrate towards other livelihoods rather than fishery due to the unsatisfactory economic performance of the sector and inferior social drivers in the villages. The presently studied communities were also not found to be oriented properly as they lack adequate affiliation with community groups and fisheries co-operatives.

The cost of living is continuously increasing, whereas the income from the fishing was found to be decreasing which is primarily due to the increased cost of fishing. The fishing cost has increased due to the shift in fish abundance and the fishers have to move beyond the traditional fishing grounds in search of commercially important fishes. The decrease in income from fishery is mainly because of escalation in input costs due to increasing cost of fossil fuel, fishing gear and boat coupled with the economic loss due to spoilage of the catch as the fishers are nowadays voyaging to farther grounds for fishing. Moreover, the income from fishery is also declining due to erratic monsoon and extreme weather events, which is decreasing the number of fishing days. The lack of financial capital and poor accessibility to credit facility prevent the fishers from augmenting their physical assets such as boats, nets and other safety measures. The fishery as a vocation is highly seasonal in nature and there is an acute scarcity of alternative livelihood in the coastal areas, which is diminishing the adaptive capacity of fishers against adverse impacts of climate change. In the present study, most of the fishers (about 71%) are uneducated, because of which they are not able to take alternate vocation as adaptive measures. The findings of the present study is found to be in congruence with the earlier studies, where the communities which were most underprivileged (Islam *et al.*, 2014), low per capita income (Das *et al.*, 2014) and poor (Paavola, 2008, Black *et al.*, 2011, Deressa *et al.*, 2011) have been identified as most vulnerable communities. Since the fishermen societies were mainly dependent on fishery activities, other activities like animal husbandry and livestock farming activities were found to be minimal and negligible.

In recent days, there has been a considerable development in residential area and coastal tourism sector, which are mostly appearing to be unplanned and unsustainable. The anthropogenic pollutants such as uncontrolled use of plastic, agriculture fertilizers and lack of effluent treatment plants are deteriorating the marine ecosystem. Changes in land use pattern could possibly magnify the effects of extreme climate events like fatalities from storms and other infectious diseases (Patz and Campbell, 2005). Similarly, the unregulated expansion of industries, chemical and power plants are further inflaming the situation. The effect of non-climatic drivers such as urbanization, land reclamation, usage, degradation and pollution has been well discussed (IPCC, 2007). Despite the huge technological revolution, most of the fishing boats are not yet equipped with communication and early warning facilities, which is greatly decreasing their adaptive capacity against the hazardous effects of climate change. Similarly, the inadequacy at the policy, planning and implementation levels such as inadequate disaster preparedness, rehabilitation measures, incentives and economic supports for the affected is declining the capacity of the community to cope with the changing climate. Smit and Wandel (2006) in their study have discussed in detail about various parameters on which the adaptive capacity of fishers depend and concluded that adaptation measures should be the prime focus while forming the various policies to counteract the impact of climate change.

Conclusion

The results of the present study are providing necessary inputs to understand the vulnerability and impacts on fishing communities due to the climate change. From the study, it is apparent that the economic performance of the sector is going to be impacted more compared to the other parameters, which will compromise the adaptive capacity of the fishermen. This adverse impact could aggrandize and pose serious threats because of higher sensitivity of the community due to inadequate social performance, which ranked as the second most impacted parameter. The study clearly reveals that there is an urgent need for awareness building among the coastal fisher folk on the climate change and related threats to the livelihood. There is also a need for devising adaptation strategies through proper scientific interactions and trainings. It further concludes that the developmental and welfare activities in the coastal areas need to be planned in a climate change perspective equipping the coastal population to adapt to changes in climate scenario. Similarly, mitigation strategies should be made by providing adequate infrastructure in the working areas and by creating opportunities for alternate vocations.

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References

Allison, E.H, Adger, W.N, Badjeck, M.C. and Brown, K. 2005. Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisher folk living in poverty final technical report. Fisheries Management Science Programme (FMSP), Portsmouth.

Allison, E.H., Perry, A.L., Badjeck, M., Adger, W.N., Brown, L. and Halls, A.S. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. Fish Fisheries, 10:173-196. http://dx.doi.org/10.1111/j.1467-2979.2008.00310.x

Badjeck, M.C., Allison, E.H., Halls, A.S. and Dulvy, N.K. 2010. Impacts of climate variability and change on fishery-based livelihoods. Marine Policy, 34: 375–383. http://dx.doi.org/10.1016/j.marpol.2009.08.007

Black, R., Bennett, S.R.G., Thomas, S.M. and Beddington, J.R. 2011. Climate change: migration as adaption. Nature, 478:447-449 http://dx.doi.org/10.1038/478477a

Brander, K.M. 2010. Impacts of climate change on fisheries. Journal of marines systems, 79: 389-402. http://dx.doi.org/10.1016/j.jmarsys.2008.12.015

Chavez, F.P., Ryan, J., Lluch-costa, S.E. and Niquen, M.C. 2003. From anchovies to sardine and back: multidecadal changes in Pacific Ocean. Science, 299: 217-221. http://dx.doi.org/10.1126/science.1075880

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R. and Pauly, D. 2009. Projecting global marine biodiversity impacts under climate change scenario. Fish Fisheries 10:235–251

CMFRI 2014. Central Marine Fisheries Research Institute, Annual Report 2013-2014. ICAR, Cochin, Kerala, India.

CMFRI 2015. Central Marine Fisheries Research Institute, Annual Report 2014-2015. ICAR, Cochin, Kerala, India.

Cutter, S.L., Emrich, C.T., Webb, J.J. and Morath, D. 2009. Social vulnerability to climate variability hazard: a review of literature (online) 2009 USA, Hazard and Vulnerability Research Institute and University of South Carolina

Das, M.K., Srivastava, P.K., Rej, A., Mandal, M.L. and Sharma, A.P. 2014. A framework for assessing vulnerability of inland fisheries to impacts of climate variability in India. Mitigation and Adaptation Strategies for Global Change, DOI 10.1007/7s11027-014-9599-7

Daw, T., Adger, W.N., Brown, K. and Badjeck, M.C. 2009. Climate change and capture fisheries: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto and T. Bahri (eds). Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530, Rome, FAO. 107-150 pp..

Deressa, T., Hassan, R.M. and Ringler, C. 2011. Assessing household vulnerability to climate change. The case of farmers in the Nile Basin of Ethiopia. International food policy Research Institute, Washington.

Drinkwater, K.F., Beaugrand, G., Kaeriyama, M., Kim, S., Ottersen, G., Perry, R.I, Portne,r H.O. Polovina, J.J. and Takasuka, A. 2010. On the processes linking climate to ecosystem changes. Journal of marines systems, 79: 374–388 http://dx.doi.org/10.1016/j.jmarsys.2008.12.014

FAO 2010. The state of world fisheries and aquaculture 2010. FAO Fisheries and Aquaculture Department, Food and agriculture organization of United states, Rome.

Gerald, C.N., Mark, W.R., Jawoo, K., Richard, R., Timothy, S., Tingju, Z., Claudia, R., Siwa, M., Amanda, P., Miroslav, B. and Marilia, M. 2009. Climate Change: Impact on agriculture and cost of adaptation. Report in International Food Policy research Institute, Washington D.C.

Harmeling, S. 2011. Global climate risk index 2011 who suffers most from extreme weather events? Weather related loss events in 2009 and 1990 to 2009. A briefing paper, Germanwatche. V. 24

IPCC Climate Change 2001. Impacts, Adaptation and Vulnerability, McCarthy,J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., and White, K.S., (eds.), Cambridge: Cambridge University Press.

IPCC Climate change 2007. Impacts, adaptation and vulnerability: contribution of working group II to the third assessment report of Inter governmental Panel of Climate Change. In: Parry ML, Canziani OF, paluti of JP, van der Linden PJ, hanson CE (eds) Cambridge university Press, Cambridge.

IPCC Climate Change 2007. The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B.Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge, pp 996.

Islam, M.M., Sallu, S.M., Hubacek, K. and Paavola, J. 2014. Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. Regional Environmental Change, 14 (1): 281 - 294. http://dx.doi.org/10.1007/s10113-013-0487-6

Lehodey, P., Chai, F. and Hampton, J. 2003. Modelling climate related variability of tuna population from a coupled ocean biogeochemical populations dynamics model. Fisheries Oceanography , 12: 483-494 http://dx.doi.org/10.1046/j.1365-2419.2003.00244.x

Marine fisheries Census 2010. Marine Fisheries Census 2010 Part II. 10 Gujarat, Ministry of Agriculture, Krishi Bhavan, New Delhi and CMFRI Kochi (2010). CMFRI, Kochi.

NPCC 2008–2009. Network Project on Climate Change 'Impact, Adaptation and Vulnerability of Indian Agriculture to Climate Change Annual Report (2008–2009).

Paavola, J. 2008. Livelihood, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environmental Science & Policy, 11: 642-654 pp http://dx.doi.org/10.1016/j.envsci.2008.06.002

Patnaik, U. and Naryanan, K., Vulnerability and climate change 2005. An analysis of the eastern coastal districts of India. Paper presented at the International workshop on Human security and climate change, Oslo, 21-23 June 2005.

Patz, J.A., Campbell-Lendrum, D., Holloway, T. and Foley, J.A.N. 2005. Impact of regional climate change on human health. Nature, 438: 310-317 http://dx.doi.org/10.1038/nature04188

Perry, R.I., Omnmer, R.E. Allison, E., Badjeck, M.C., Barange, M., Hamilton, L., Jarre, A., Quinones, R.A. and Sumaila, U.R. 2009. The human dimensions of marine ecosystem change: Interaction between changes in marine ecosystem and human communities. In: barange M, field C, harris R, Hofmann E, Perry I, Werner C (eds) Global Change and Marine ecosystems. Oxford University press, Oxford.

Sabarathanam, V.E. Manuals of fields Experience Training for ARS Scientist 1988. Hydrabaad, NAARM.

Salagrama, V. 2012. Climate change and fisheries perspectives from small scale fishing communities in India on measures to protect life and livelihood. Samundra Monograph, International Collective in Support of Fishworkers.

Sano, M. , Golshani, A., Splinter, K. D., Strauss, D., Thurston, W. and Tomilson, R. 2011. A detailed assessment of vulnerability to climate change in the Gold Coast, Australia. Journal of Coastal Research, 245-249.

Sarch, M.T. and Allison, E.H. 2000. Fluctuating fisheries in Africa's inland waters: well adapted livelihoods, maladapted management. In proceedings of fisheries economics and trade, Corvallis, 9-14 July 2000

Shyam, S.S., Kripa, V., Zacharia, P.U., Mohan, A., Ambrose, T.V. and Rani, M. 2014. Vulnerability assessment of coastal fisher household in Kerala: A climate change perspective. Indian Journal of Fisheries, 61(4):98-103

Shyam, S.S., Kripa, V., Zacharia, P.U., Nivedita, S. and Ambrose, T.V. 2011. Climate change awareness, preparedeness, adaption and mitigation strategies: fisherfolks perception in costal Kerala. Journal of Aquatic Biology and Fisheries, 2: 670-681.

Smit, B. and Pilifosova, O, 2001. Adaptation to climate change in the context of sustainable development and equity. Chapter 18 in Climate Change 2001: Impacts, Adaptation, and Vulnerability-Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16:282-292 http://dx.doi.org/10.1016/j.gloenvcha.2006.03.008

Srinath, M., Beena, M.R., Augustine, S. K, Kuriakose, S. and Sreenivasan, J. 2007. Marine Fisheries Profile Gujarat, e-prints, Central Marine Fisheries Research Institute (CMFRI), Kochi, India.

Tesso, G., Emana, B. and Ketema, M. 2012. Analysis of vulnerability and resilience to climate change induced shocks in North Shewa, Ethipoia. Agricultural Science 3(6):871-888 http://dx.doi.org/10.4236/as.2012.36106

Vass, K.K., Das, M.K., Srivastava, P.K. and Dey, S. 2009 Assessing the impact of climate change on inland fisheries in River Ganga and its plains in India. Aquatic Ecosystem Health & Management, 12:138–151 http://dx.doi.org/10.1080/14634980902908746

Vivekanandan, E and Jeyabaskaran, R 2010. Impact and adaptation options for Indian marine fisheries to climate change. Book chapter in climate change adaptation strategies in agriculture and allied sectors. Scientific publishers, New Delhi, 107-117 pp.

Vivekanandan, E., Rajagopalan, M. and Pillai, N.G.K. 2009a. Recent trends in sea surface temperature and its impact on oil sardine. In: impact, adaptation and vulnerability of Indian agriculture to climate change (Aggarwal, P.K., Ed.), Indian Council of Agricultural Research, New Delhi (in press).

Vivekanandan, E. and Rajagopalan, M. 2009. Impact of rise in seawater temperature on the spawning of threadfin breams, In: impact, adaptation and vulnerability of Indian agriculture to climate change (Aggarwal, P.K., Ed.), Indian Council of Agricultural Research, New Delhi. (in press)

World fish centre 2007. The threat to fisheries and aquaculture from climate change, policy brief.