



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 approach 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 Arabian 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 $\alpha=n$

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 through the environment related indirect pathways were assessed using five attributes (Figure 2). Sensitivity was defined as the degree and velocity of an adaptive livelihoods would be affected due to the impacts of above mentioned attributes. The sensitivity of the system was measured using fishery and social parameters. The relative weight score index (RWS) sensitivity PARS (P-fishery, and social, Resilient indicator and Score) methodology (Shyam et al., 2011

conceptual climate change PARS methodology ranking of fishers. Five the attributes were scored interviewing standard procedure fishers were indicator from being very negligible/n results obtained analyzed using The analysis value measured

RWS

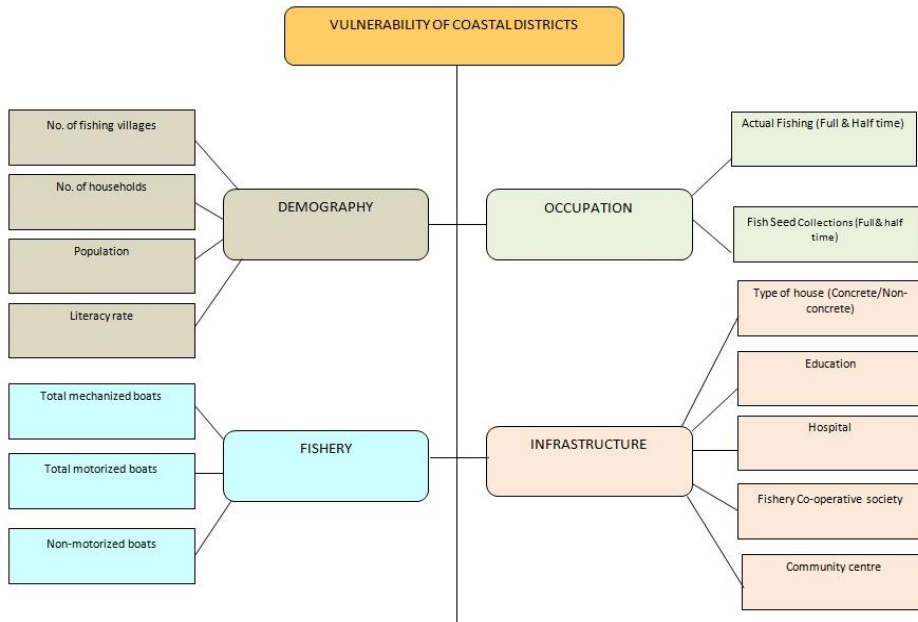


Figure 1. Framework for assessing the vulnerability of coastal districts

Where, F_i : Frequency of fishers for the i^{th} rank of statements
 r_i : Assigned rank
 N : No. of fisher
 N : No. of problem

Results

The initial identification of vulnerability indicators in coastal districts using methodology of Narayanan (2005), value was obtained

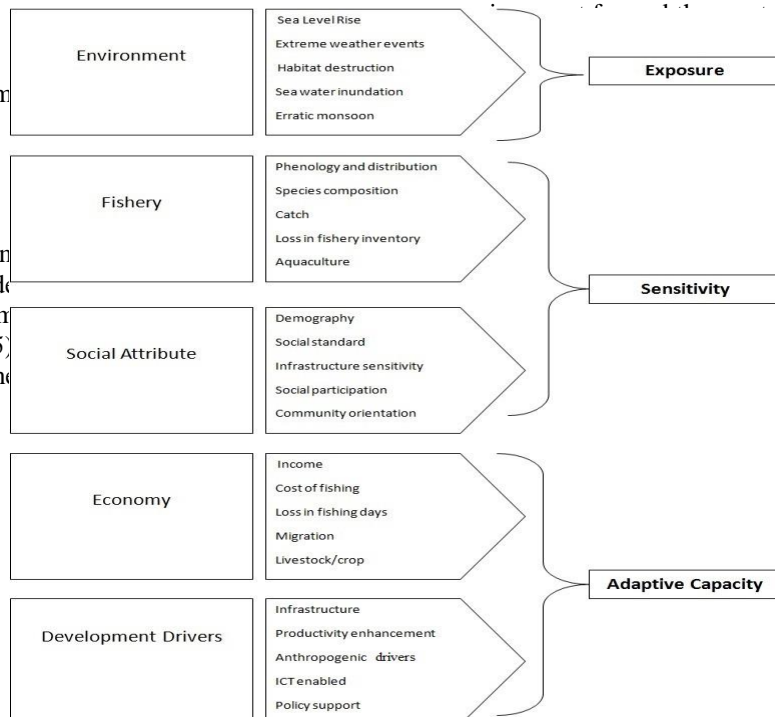


Figure 2. Framework for construction of vulnerability index including parameter and attribute used in PARS methodology.

related issues were shown in Figure 2. The adaptive capacity of the fishery livelihood of coastal villages the potential of such livelihoods, which have higher changeability to overcome the potential change of unattractive disadvantage opportunity of fish with the consequences about 27 fishing villages with a total population of 2,07,076. The adaptive capacity of the coastal livelihood economy was obtained from the fishery village followed by Old lighthouse, Navabunder,

and as candidate Figure 3). parameters across and to be most change. Since the area is an the adaptive the system is the impacts of le impacts of followed by social sensitivity of the system to the y environment bird among the however, little age level, thus susceptible to e. The study fact of climate id Navabunder 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, impacted parameter as a liya, which could be pollution caused by industrial Development nomic Zone (SEZ) in ferrying goods. The te impacted by the of study was ‘Social population was found prone to disaster and sanitation facilities

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

Sensitivity Vulnerability of coastal villages of Junagadh District

Taluk	Village	VI
Taluk 1	Kodinar	0.26
Taluk 1	Kaj	0.91
Taluk 1	Kotada	0.29
Taluk 1	Maliyaha	0.22
Taluk 1	Mudising	0.29
Taluk 1	Velan	0.27
Taluk 2	Maliyaha	0.22
Taluk 2	Chorwad Bunder	0.22
Taluk 3	Mangrol	0.49
Taluk 3	Mangrol Bunder	0.18
Taluk 3	Mangrol Bara	0.24
Taluk 3	Shil Bunder	0.24

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 to be 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

Village	VI	Taluk	Village	VI
Dhamlaj	0.22	Taluk 6	Una	0.19
Hirakot	0.17	Taluk 6	Dhundi	0.25
Bunder	0.31	Taluk 6	Delwada	0.18
Sutrapad	0.18	Taluk 6	Kalapan	0.22
Veraval	0.18	Taluk 6	Kheda	0.22
Bara	0.25	Taluk 6	Kob	0.28
Jaleshwar	0.25	Taluk 6	Jaleshwar	0.28
Veraval	0.31	Taluk 6	Manekpur	0.21
Bhidiya	0.54	Taluk 6	Navabunder	0.32
Veraval old light house	0.54	Taluk 6	Paldi	0.28
		Taluk 6	Rajpara	0.39
		Taluk 6	Seemar	0.22
		Taluk 6	Senjaliya	0.24

* Vulnerability Index (VI)

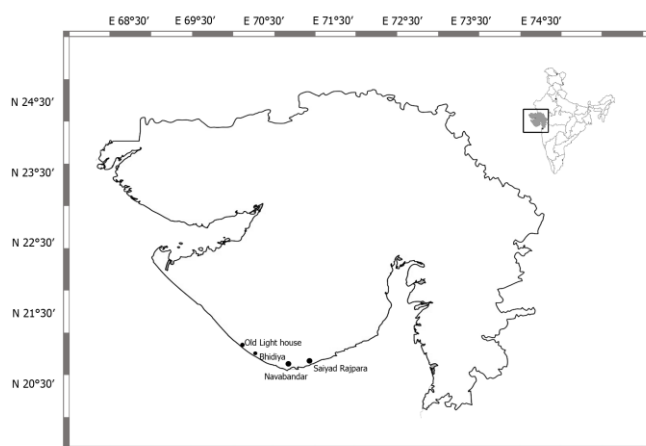


Figure 3. Study area depicting the vulnerable coastal villages along the Gujarat Coast.

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

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 which are effectively dim the fishing and thus decrease. The third worst impacted income effect followed by other livelihood options. It was found to be least impacted these villages (Figure 8)

Nevertheless, the development level, were also perceived intensifying the impact of fisher household. The attributes

include coastal 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

fishery based livelihoods of the highest vulnerability among Gujarat. Assessment of the loss the fishing villages of the economy forms the most due to the consequence of the social and

rs. Longing of the windy days of their unseasonal occurrence is total active fishing days in a following the monsoon was fish landing period and any aberrations in weather

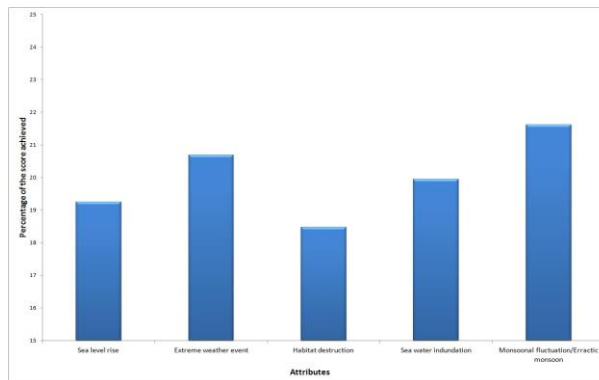
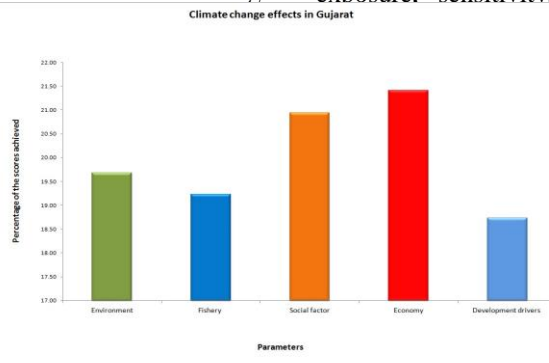


Figure 5. Attribute analysis of climate change impact on environment.

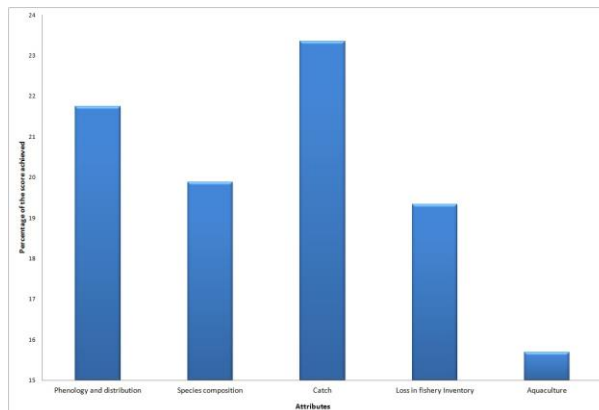


Figure 6. Attribute analysis of climate change impact on fishery.

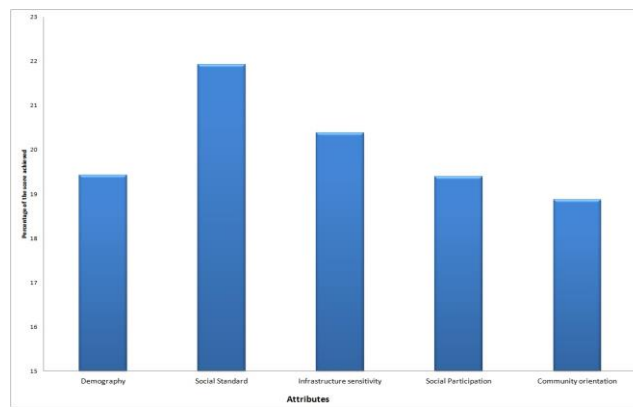


Figure 7. Attribute analysis of climate change impact on social parameter.

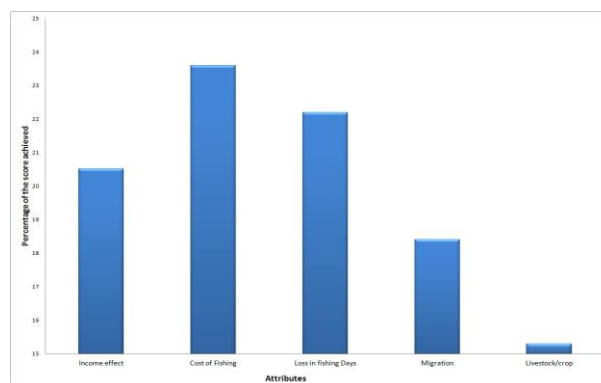
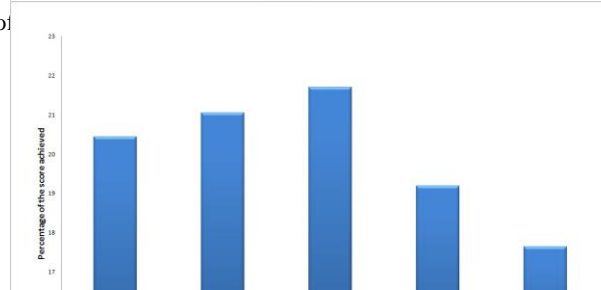


Figure 8. Attribute analysis of climate change impact on economic parameter.



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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