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Local Vulnerability Assessment of Climate Change and its Socio-Economic Implications: A Case of 'Koli' Communities of Mumbai

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Abstract: The main purpose of this study is to understand and assess the socio-economic implications of climate change on fishery communities and their livelihood. A primary survey of 164 fishermen families from five fishing villages of Mumbai known as 'Koliwada' is conducted, and a set of vulnerability indicators are derived. These indicators are further measured based on expert opinions. The vulnerability indicators are selected on the basis of an extended literature review pertaining to climate change vulnerability assessment and adaptation. Vulnerability is considered as the combinations of both sensitivity and adaptive capacity. The sensitivity indicators are further divided into two categories: livelihood and perceived changes, similarly the indicators of adaptive capacity are of five categories comprising human, physical, financial, social and government policy related. Thus a total 30 indicators are selected for the study. The study found Madh and Worli fishing villages along the coast of Mumbai are more vulnerable having high sensitivity and low adaptive capacity among the fishing villages selected for study. The vulnerability scores for social resources and government policy related scores are low and close to zero implying high adaptive capacity among fishermen, whereas in terms of physical resources and financial resources, the vulnerability scores differ among villages showing varying adaptive capacity. These derived vulnerability scores can be very useful for considering various policy measures in fishing villages.

1. Introduction

Climate change affects people and places differently. The socio-economic impacts of climate change on sectors like agriculture, forest, and fishery can be very direct in terms of affecting the production of those sectors. On the other hand rising sea levels and extreme events (like; heavy rain falls, floods and cyclones) can cause extensive damage to property, human live loss, livelihood loss, health impacts, loss of recreational activities etc. The most affected regions to such changes are coastal areas. The concentration of urban population and economic activities near coastal areas is increasing rapidly (McGranahan *et al*., 2007). It is estimated that, many of the coastal cities and coastal populations in Africa, Asia, and Latin America are at risk from flooding. According to Asian Development Bank (ADB, 2009), 60 million people in South Asia are living in high-risk coastal flooding zones. The coastal areas of countries like Bangladesh, India, Maldives and Sri-Lanka are more vulnerable to floods. The frequent monsoon rains and tropical cyclones are causing considerable damage to critical infrastructure in the coastal areas of these countries. However, within coastal areas the low-income groups living on flood plains are especially vulnerable to such changes.

India has more than 8000 km long densely populate, fragile and highly productive coastal ecosystem which includes a huge marine biological diversity and the largest number of commercial fish species in the world. Fish is an important source of food as well as employment, income and foreign exchange for India (ICSF, 2001). However, the densely populated and low-laying coastal areas are exposed to frequent occurrence of cyclones, storms, and environmental degradation. The change in climate is expected to increase the frequency and intensity of these events. A significant proportion of the population from coastal areas in India also lives in poverty, and from environmental and socioeconomic points of view, coastal fishing communities are among the most vulnerable.

The paper is divided into nine sections; Section 1 is based on the introduction of issues. Section 2 deals with the issues of climate change in coastal areas of India. The section derives evidences from literature surveyed. In section 3 problem of climate change for Mumbai are presented. Increase in rainfall, change in rainfall pattern and flood related problems for Mumbai are analyzed. Section 4 provides the profile of fishing 'Koli' communities of Mumbai. In section 5 the study design and sample village selection and details on questionnaire are discussed. In section 6 the process of developing vulnerability indicators, the weight allocation methods are presented. Section 7 deals with the socio-economic profile of sample data. Section 8 provides the results of vulnerability assessment. Section 9 is the conclusion and policy implications.

2. Climate Change Issues and Concerns

Observations suggest that the sea level has risen at a rate of 2.5 mm per year along the Indian coastline since 1950s. A mean SLR of between 15 and 38 cm is projected by the mid- 21st century along India's coast. Added to this, a 15% projected increase in intensity of tropical cyclones would significantly enhance the vulnerability of population living in cyclone prone coastal regions of India (Aggarwal and Lal, 2009). Shetye *et al*. (1990) studied vulnerability of Indian coastal region to the consequences of the estimated SLR due to green house effect. The study found the most vulnerable regions to SLR are the low-lying areas of Lakshadweep Island and the east coast region. The east coast region is more vulnerable to the frequency of storms. The study conducted by Jawaharlal Nehru University and by The Energy Research Institute (TERI, 1996) found the physical impacts of 1 metre SLR as the loss of 5763 km^2 (or 0.41%) combined area of the coastal states. A total of 7.1 million people are found to be at risk, representing 4.6% of the total coastal population. Gujurat and West Bengal are the most affected states in terms of land area loss to 1 metre SLR, similarly in terms of population, Tamil Nadu and Maharashtra are the most affected because of their high density of coastal population. Considering the impact at district level, Mumbai is found to be highest vulnerable to land loss and population affected. In terms of land use, cultivated land is the most affected in West Bengal, Odisha, and Maharashtra. In terms of settlement land, Maharashtra and Gujurat are the most vulnerable states (Noronha *et al*., 2003). The estimated economic costs for the 1 meter SLR range from Rs 2287 billion in the case of Mumbai to Rs 3.6 billion in Balasore districts of Odisha where the impacts are likely to be less (Gupta, 2004).

Increased flooding and salt-water intrusion have direct effect on coastal agriculture, fisheries, aquaculture, freshwater resources, human settlements and tourism. The impact of climate change can also be related to the loss of biodiversity in coastal areas. The vulnerability atlas of India shows 8.5% of total land in India is vulnerable to cyclones, 5% of land vulnerable to floods and 1 million houses are vulnerable to damage annually. Between 1877-2005 total 283 cyclones (among those 106 severe cyclones) occurred in a 50 km wide strip on the east coast whereas comparatively less severe cyclones occurred on west coast (total 35 cyclones). In 19 severe cyclonic storms death toll greater than 10,000. The super-cyclone of 1999 wreaked havoc in coastal Odisha claiming more than 30,000 human lives.

A number of studies estimating vulnerability of India's coastal region are macro level studies. Studies have considered the country as a whole or, coastal states or coastal districts as the unit of analysis. However India is a vast country having diversely geographic, economic, cultural etc. The coastal fishing communities living close to the sea are always vulnerable to climate change and other related impacts. The fisheries sector make important contributions to local development in coastal regions, provides huge employment and diverse livelihood. Fishing livelihood also provides useful platforms to study adaptation because fishing community is well known for being reactive to changes in environment, markets, and an unpredictable resource base (Coulthard, 2008). Fishing communities depend mostly on natural resources for their livelihood whose distribution and productivity are known to be influenced by climate dynamics.

3. Climate Change and Mumbai

The Canadian climate centre‘s A2 (business as usual) and B2 (sustainable path) scenarios predict an average annual temperature increase of 1.75^{o}C and 1.25^{o}C, respectively, by 2050 for Mumbai (Sherbinin *et al*., 2007). Similarly an average annual decrease in precipitation of 2 percent is predicted for the A2 scenario and an increase of 2 percent for the B2 scenario whereas both the scenarios are predicted for a decrease in rainfall during the first half of the year i.e. January to August and an increase in rainfall from September to November. The following table shows some of these changes are already been experienced in recent years. Temperatures for the month of March to May has been increasing, in 2011 the highest temperature was 41.6 ^{0}C on 16th March. Change in the rainfall pattern is also persisting. The average annual rainfall of Mumbai is 2504 mm. 70 % of this occurs in July and August with 50 % occurring in just 2 or 3 heavy rainfall events. The Santa Cruz meteorological station at Mumbai airport recorded 944 mm of rainfall during a single day on 27th July 2005. Mumbai depends heavily on rainfall for the water supply and with the change in hydrological cycle the problem of water shortage is going to be more intense for the years to come.

Table 1: Monthly rainfall for Greater Mumbai region[1]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Octo.	Nov.	Dec.	Total
2007	0.0	2.3	0.0	0.0	0.4	776.6	650.9	646.2	428.7	0.0	3.8	0.0	2508.9
2008	0.0	0.0	0.1	0.0	0.5	768	910.2	498.8	338	15.4	1.6	0.2	2532.8
2009	0.0	0.0	0.0	0.0	1.3	241	956.8	274.4	420.8	190.8	105.4	0.0	2190.5
2010	0.0	0.0	0.0	0.3	0.0	947.4	1112.7	860.7	272.9	122.4	55.7	0.0	3372.1
2011	0.0	0.1	0.0	0.0	0.7	461.2	1284.4	796.8	362.5	65.6	0.0	0.0	2971.3
2012	0.0	0.0	0.0	0.0	0.0	176.9	392.5	520.2	343.3	127.1	0.0	0.0	1560

Source: India Meteorological Department (IMD).

Table 2: Minimum and Maximum Temperatures and Highest 24hr rainfall event for Mumbai

Mumbai	Minimum Temp. (^0C)	Date (Month/Day)	Maximum Temp. (^0C)	Date (Month/Day)	Highest 24 hr rainfall (mm)	Date (Month/Day)
2012	12.5	30-Jan	35.6	5-June, 28-Oct	112.6	31-August
2011	15.8	16-Feb	41.6	16-March	210.9	31-July
2010	17	20-Dec	37	17-April, 26-27May, 5-June	210	25 June
2009	17	1-Jan, 2-Dec	37	6-10 April	194	4-Sept
2008	12	9-Feb	36	20-May, 2-June	249.7	28-July
2007	18	17-23 Jan, 29-30 Dec	36	5-April	279	24-June
2006	17	4-27, 29 Jan	35	21-23 May, 6-14 June	231	5-July
2005	15	19-Jan, 22 Feb	36	4 April		

Source: Indiastat.com

Flooding is a very common problem in Mumbai, when heavy rainfall coincides with high tides of 4-5 m at that time or storm surges. Increase in rainfall and rise in the sea level along with the poor drainage system of the city will further increase the frequency and severity of floods. Predicted climate models suggest that the hydrological cycle will be affected by climate change, with the intensity of heavy rainfall events rising and the number of rainy days decreasing

[1] The district (Mumbai including Mumbai sub-urban) rainfall (mm) shown here are the arithmetic averages of rainfall of all stations (Colaba and Santacruz) under the district

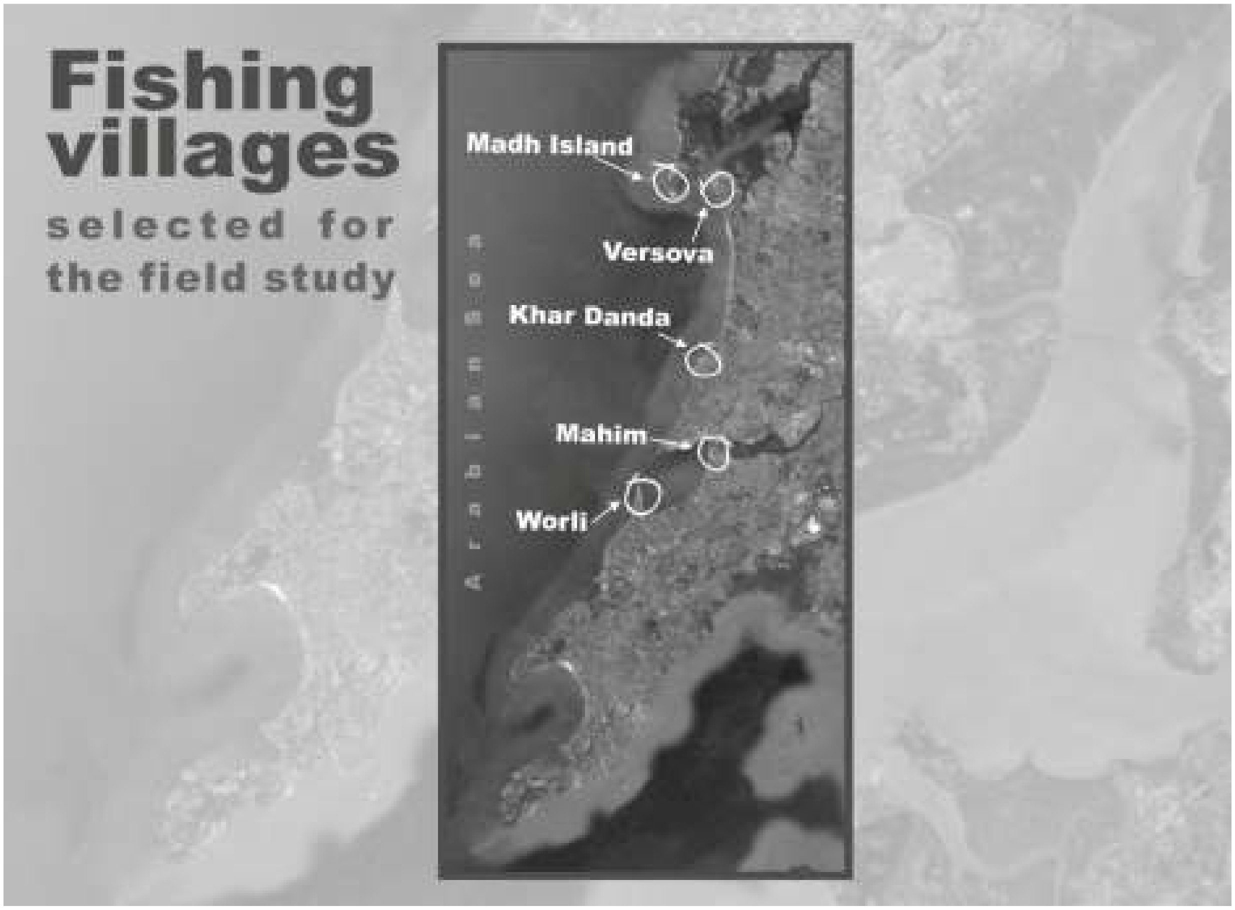
(Challinor *et al.,* 2006; Ranger *et al.,* 2011). The failure of monsoon and change in rainfall pattern caused severe floods in the year 2002, 2005, and 2007. In July 2005, the city received an unprecedented 944 millimeters of rainfall in a 24-hour period. It has been observed that till 1989 the average rainfall of Mumbai was 2129 mm. However, in 2005-2006 the average annual rainfall was found to be of 3214 mm (Kumar *et al.,* 2008), an increase of 50% resulting the most devastating floods in the recent history leaving more than 500 people dead, mostly in slum settlements. The estimated direct economic damage was more than Rs 5000 crores. One million people rendered homeless (Jenamani *et al.*, 2006). The likelihood of 2005-like event is more than double and the extreme rainfalls could become more frequent in India under the impact of climate change. The low-income groups and poor residents living in vulnerable and low lying areas (accounting for nearly 50% of Mumbai's population) will be affected more. Urbanisation has been an important driver of increased flood risk in the city. The drainage systems of the city are now inadequate to cope with heavy rainfall and are impeded by urban encroachment and channel blockages.

4. Fishing Villages and Issues

The Koli communities are the oldest residents of Mumbai. The word Koli refers to fishermen and includes a number of castes and groups. Majorly the Son-Kolis living in and around Mumbai are almost exclusively involved in active fishing. Son-Kolis are the original residents of Mumbai since the time of Portuguese and British rule in India. Mahadev Kolis are migrants from the other regions of Maharashtra. Together, these two communities comprise the bulk of the fishery community in Mumbai (Ranade, 2008). According to the marine fishery census (MFC, 2010), there are 30 fishing villages in Mumbai. The total Koli population in Mumbai is more than 40,953 in 2010 which was 50, 075 in the year 2005, similarly the number of fishing families also declined from 10, 082 in 2005 to 9304 in 2010. There are 612 families in Mumbai living below poverty line (BPL) according to the census 2010. Although the number of fishing villages in Mumbai is less in comparison to other districts of Maharashtra, they are found to be overcrowded with the increasing number of populations. There are various reasons underlying for the decrease in number of fishery population and families, the traditional fishermen finding it difficulty with the modernization and entry of non-fishery people to the business, the use of heavy mechanized boats, modern technologies only helped a few of the family in Koliwada. Climate change and depleting in fishery resources, non-availability of fish are also other causes of fishermen losing their livelihood.

5. Survey Design and Sampling

The pilot survey, secondary data analysis, and the discussions with various stakeholders (fishermen, government officials, and scientist from Centre for Marine Research Institute) helped the selection of five villages (Versova, Madh, Khar, Mahim and Worli) for primary data collection for the present study area. The pilot survey and in the latter stage the primary survey was conducted through a structured questionnaire based on the livelihood analysis. The survey was conducted over six months starting with the fishing season in the year 2011 (mid August to February 2012). The unit of the survey was households.



Map 1: Fishing villages selected for the field study

The survey questionnaire consisted of ten sections that broadly reflect the five types of assets considered by SLA (Scoones, 1998; Allison and Ellis, 2001). These sections are (i) Households demographic information, (ii) Occupation, migration and other characteristics, (iii) Households physical assets, (iv) Family income and expenditure, (v) Borrowings and Savings, (vi) Climate change perceptions, (vii) Marketing issues, (viii) Health issues, (ix) Other social issues, (x) Adaptation measures. The household from each of the five villages are selected randomly. The households are explained about the objectives of the primary survey before the start of the interview.

6. Vulnerability assessment

Vulnerability reduction and sustainable development are two important elements of adaptation to climate change. Adaptation in this context is looked through a wide variety of economic, social, political, and environmental circumstances (Senapati and Gupta). In this paper household vulnerability indicators are developed with the help of sustainable livelihood approach (Badjeck *et al*., 2010) and Analytic Hierarchy Process (AHP) (Saaty, 1980), an important tool of multi-criteria analysis.

6.1 Vulnerability indicators and its development process

Indicators are especially developed in order to compare vulnerability of two regions (like HDI), however these indicators involves many uncertainties in finding appropriate scale and criteria for aggregating indicators. For example at national level, the indicators of adaptive capacity depend on financial capacity and institutional capacity of a country for making resources availability for the most vulnerable areas and people. Whereas at household level, the adaptive capacity of a person depends on his knowledge, perception towards climate change which helps in indentifying new or modified livelihood opportunities and access to resource for achieving this (Vincent, 2007). Many of the vulnerability indicators (Moss *et al*., 2001; Adger *et al*., 2004) developed so far are data driven or based on inductive approach. The common methodologies used for this are Factor Analysis, Principal Component Analysis, expert judgment, or correlation analysis. On the other hand theory-driven approach uses theoretical insights into the nature and causes of vulnerability for deriving the indicators. Hahn *et al.* (2009) used a deductive approach for selecting vulnerability indicators for Mozambique and developed a 'livelihood vulnerability index'. The selection method is based on the literature survey related to the Sustainable Livelihood Approach. They also used primary data at household level. However these local level theories only provide arguments for the selection and not for the aggregation of indicating variables. Ekin and Luis (2008) used multi-criteria analysis to assign weights to indicators along with livelihood approach for measuring vulnerability for agricultural household of Tamaulipas, Mexico.

6. 2 Multi-criteria Decision Analysis (MCDA)

Multi-criteria analysis is a type of decision analysis tool that is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) falls short, especially where significant environmental and social impacts cannot be assigned monetary values. MCA allows decision makers to include a full range of social, environmental, technical, economic, and financial criteria i.e., when multiple options are to be evaluated against multiple criteria. The climate change related problems have far reaching economic and ecological implications, and simultaneously the socio-economic dimensions are needed to be considered. The application of multi-criteria analysis also deals with the uncertainty associated in measuring the above indicators. Multi-criteria framework is therefore considered as a paradigm for the whole field of ecological economics (both macro and micro analysis) and the use of multi-criteria analysis is a desirable tool (Mumnda *et al*., 1994; Alier *et al*., 1998; UNFCCC, 2008).

In MCA, desirable objectives are specified and corresponding attributes or indicators are identified on the basis of chosen criteria to achieve the objectives. The actual measurement of indicators need not be in monetary terms, but are often based on the quantitative analysis (through scoring, ranking and weighting) of a wide range of qualitative impact categories and criteria. Multi-attribute value theory (MAVT), multi-attribute utility theory (MAUT), and the analytic hierarchy process (AHP) are the most common approaches within multi-criteria analysis (Ananda and Herth, 2009).

6.3 Analytical Hierarchy Process

The most widely used method of MCA is the Analytic Hierarchy Process. The AHP model was initially developed by Thomas L. Saaty (Saaty, 1980) that provides a framework to make decisions involving different kinds of concerns such as planning, setting priorities, ranking alternatives, selecting the best among a number of alternatives and allocating resources. The AHP model has been applied in a wide range of areas, including natural resources, to analyze preferences for management objectives and alternatives (Ryu *et al*., 2011). In case of climate change vulnerability assessment, the AHP model can be applied to indicators measurement of individual preferences by weighting and comparing the sub-components with each other (Eakin and Luis, 2008). AHP has also been widely used in fisheries sector where studies have largely determined the relative importance of different management objectives (Innes and Pascoe, 2010). The effectiveness of the AHP resides in its capacity for decomposing the complexity of the ranking problem into a hierarchal structure, and its facility for using the capacity of human cognition to undertake paired comparisons to determine relative importance among a collection of criteria (i.e. indicators of capacity and sensitivity) (Eakin and Luis, 2008). Ramanathan (2001) has given a step wise analysis of AHP for environmental impact assessment. The initial step of AHP model is decomposition of the problem into elements according to their common characteristics and the formation of a hierarchical model having different levels. The topmost level is the 'focus' of the problem or overall goal of the analysis, which is here vulnerability assessment or deriving the vulnerability indicators for fishing communities. The intermediate levels correspond to criteria and sub-criteria, and here the criteria are selected on the basis of livelihood approach or livelihood assets (see the following figure) and their relevance for explaining the sensitivity and adaptive capacity. While the lowest level contains the 'alternatives' or indicators for measurement, those are derived from a detail literature review. Once the indicators of adaptive capacity and sensitivity identified, in the next step the elements of a particular level are compared pair wise, through a judgmental matrix that helps to elicit weights for the indicators. The last and final step of the model is to aggregate the elements and to obtain final priorities or alternatives.

6.4 Indicators Selected for the Current Study

Vulnerability is a function of exposure (IPCC, 2001b), sensitivity and adaptive capacity. Exposure and sensitivity are almost inseparable properties of a system and are dependent on the interaction between the characteristics of the system and on the attributes of the climate stimulus (Smith and Wandel, 2006; Ekin and Luis, 2008). The sensitivity and exposure indicators in the study are categorized into the livelihood indicators and indictors of perceived climate changes and climate variability. The livelihoods of fishing 'Koli' communities in Mumbai are in danger because of reduction in fish catch, hence reduction in their income. There are several factors attributed to this including climate change, overfishing, pollution, increase in diesel prices and increase in other costs. The women members of the communities, previously who supported the family financially by involving in selling and other activities are also losing their jobs because of modernization and use of technology in fishing. The problem of climate change like; rise in temperature, rise in storm and sea level, and change in rainfall pattern are affecting fishing business badly. The availability of fish and fish catches have decreased over the years, though climate change is not the only reason and over fishing can be attributed to this, but climate change remains a problem in terms of fish migration, the types of fish fishermen used to get earlier have decreased. They also have to travel longer distance for a good catch which adds to their increasing costs.

Adaptive capacity is function of the resources like; access to information, technology, institutional capacity, wealth and finance, etc. The capacity to adapt of households helps them to counteract the sensitivity and thus reduces their vulnerability. Adaptive capacity therefore is a crucial factor for determining vulnerability to climate change. At local level adaptive capacity significantly influenced by the prevailing political, social and economic conditions and the indicators of adaptive capacity can be derived from these factors. The livelihood approach was used here as a starting point. The SLA is built upon five types of assets, or capitals: human, physical, financial, social/political, and governance related. These assets help households to mitigate risk and construct viable subsistence strategies. The indicators describing human factors in the study are age, education, number of adults in the family. Similarly types of house, type of boat, having telephone/mobile, access to market and distance to hospital are selected as the indicators of physical factors. Under financial resources the indicators are total income, savings, loan, total expenditure towards fishing, whether selling fish to a middle man and subsidy. The social resources are defined by indicators such as, type of family (joint or nuclear family), existence of community hall in the society, and whether send children to school. The indicators of Government and policy resources are training, climate information or provision of early warning, insurance towards loss of boat or life loss.

The indicators are arranged in a hierarchical structure. The following figure shows the hierarchical structure linking the sub-components of vulnerability together. There are four levels in the structure, the highest level is the overall goal of the analysis i.e. obtaining the weights of vulnerability indicators, the second level represents the two sub-components sensitivity and adaptive capacity, at the third level the indicators of sensitivity and adaptive capacity are described. Sensitivity indicators are of two categories, where as the indicators of adaptive capacity is of five categories. Further at lowest or final level of the hierarchy the indicators of overall vulnerability or alternatives selected for this study are presented.

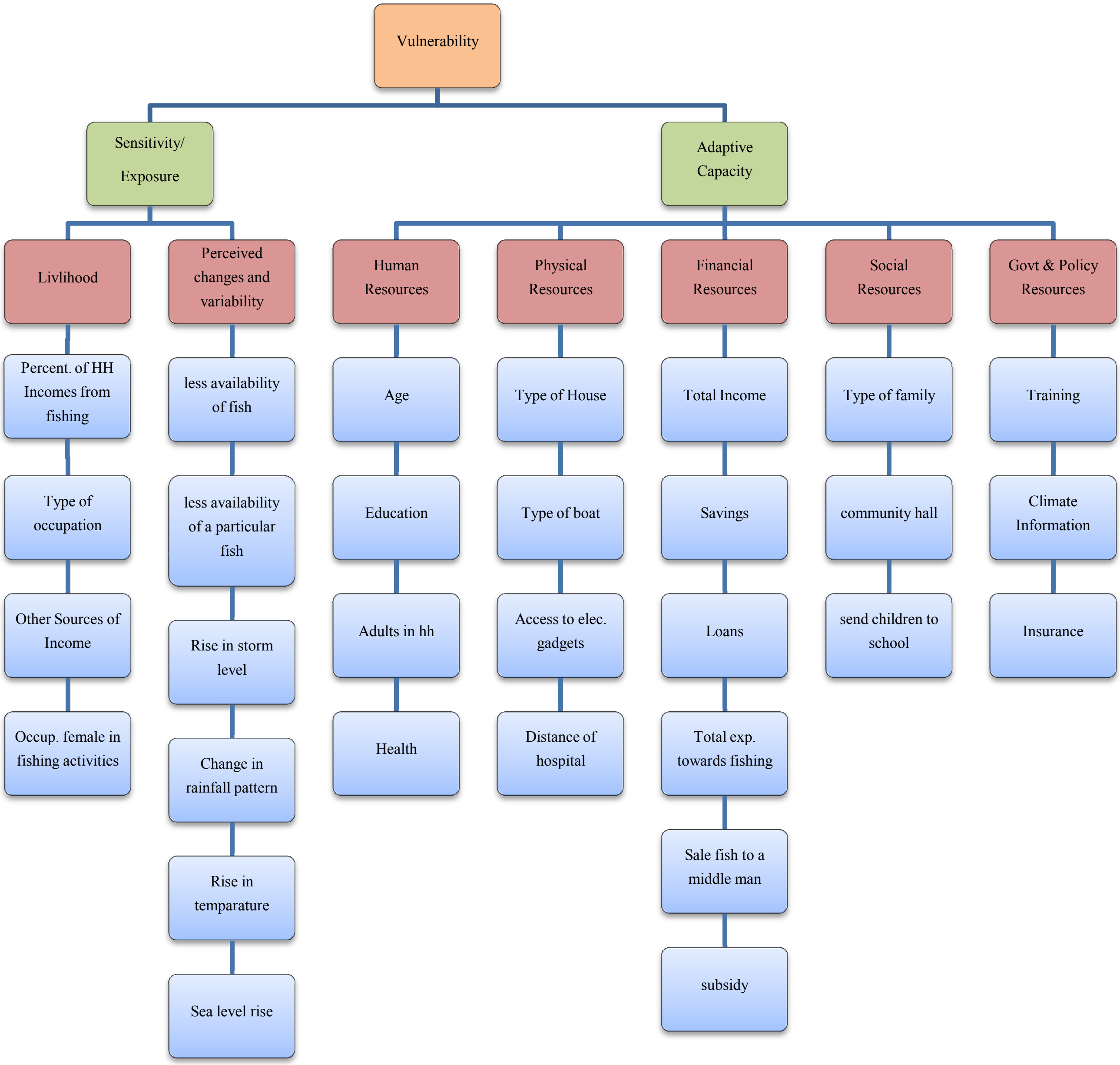


Figure 1: Indicators of Vulnerability, sensitivity and adaptive capacity selected for the current study.

6.5 Allocating weights through experts' judgments

Once the appropriate indicators of sensitivity and adaptive capacity are identified, in the next step weights of these indicators are derived through pair wise comparison of these indicators and through experts' opinion. Each of these indicators derived are different and contribute differently towards vulnerability measurement. The indicators at each hierarchical level are arranged in pair wise comparison matrices (see the following matrix in Table 3). For the current study ten such comparison matrices are prepared and presented to experts' in the form of a questionnaire. These comparisons are based on judgments by the experts/researchers of different fields from higher learning institutes in the domain of social science, technical management, scientific research institute, economics and development of the city. The experts have worked in the area of environment, climate change and indicator studies. The comparison scale includes the fundamental 9-point scale of AHP. Where 1 represents equally importance, 3, 5, 7, 9 indicates moderately, strongly, very strongly and extreme important of one indicator (row) compared to another (column) and the intermediate scores 2, 4, 6, and 8 are used for expressing intermediate importance values.

After getting the component values for each indicator from experts, the relative weights of indicators are calculated (Saaty, 2008). The comparison matrix is two-dimensional, the diagonal of the matrix are apparently takes the value 1, the values on the upper side of diagonal are given by experts and the lower side of diagonal matrix are reciprocal values needs to be filled. For example, Age of the households preferred very strongly in comparison to Adults in the household, so it takes the value of 7 in the following matrix and its reciprocal value is 1/7. Therefore only n (n-1)/2 entries needs to be fill by experts.

Table 3: Pair wise comparison scores for indicators under Human resources

Human Resources					
	Age	Education	Adults in hh	Health	Priority Vector
Age	1	1	7	3	0.44
Education	1	1	2	3	0.33
Adults in hh	1/7	1/2	1	1	0.11
Health	1/3	1/3	1	1	0.12
Sum of Columns	2.48	2.83	11	8	1

In the next step priority vector is estimated through principal Eigen values. These values are the local relative weights of each indicator. These values can be derived by summing each column of the comparison matrix, and then dividing each values of the matrix with the sum of its column values. In the next step priority vector is obtained by averaging among each row.

From the above table it is clear that age is more important indicators (44% preferred) under human resources category, next is Education (33% preferred). Health and adults in household are preferred equally and obtained nearly same score.

Table 4: Local and global normalized indicator scores obtained from an expert

Vulnerability						
Sensitivity 0.5		Adaptive capacity 0.5				
Livelihood condition	**Perceived change and variability**	**Human resources**	**Physical resources**	**Financial resources**	**Social resources**	**Govt. and policy resources**
0.83	**0.17**	**0.25**	**0.3**	**0.27**	**0.12**	**0.06**
0.42	0.08	0.13	0.15	0.14	0.06	0.03
Percent. of hh income from fishing	Availability of fish	Age	Type of house	Total income	Type of family	Training
0.55	**0.28**	**0.48**	**0.33**	**0.44**	**0.73**	**0.44**
0.23	0.02	0.06	0.05	0.06	0.04	0.02
Type of occupation	Availability of a particular fish	Education	Type of boat	Savings	community hall	Climate Information
0.2	**0.3**	**0.26**	**0.39**	**0.17**	**0.16**	**0.49**
0.08	0.02	0.03	0.06	0.02	0.01	0.02
Other source of income	Rise in storm level	Adults in hh	Access to elect. Gadgets	Loans	Send children to school	Insurance
0.17	**0.1**	**0.14**	**0.2**	**0.16**	**0.11**	**0.08**
0.07	0.01	0.02	0.03	0.02	0.01	0.01
Occu. female if fishing related activities	Change in rainfall pattern	Health	Distance of hospital	Total exp. towards fishing		
0.08	**0.18**	**0.12**	**0.08**	**0.12**		
0.03	0.01	0.02	0.01	0.02		
	Rise in temperature			Sale fish to a middlemen		
	0.1			**0.07**		
	0.01			0.01		
	Sea level rise			Subsidy		
	0.05			**0.04**		
	0			0.01		

The global weights are further calculated for each indicator by multiplying the priority vector by one of the components above. In the above the global weights for the indicators scores obtained from one expert is presented. At each level the sum of the local weights are equal to 1, and the sum of the global weights are equal to the global weight of the component above.

7. Socio-Economic Profile of Sample

The socio-economic profiling of the data is needed in order to compare and analyze various aspects of household characteristics, the perceptions of households towards climate change and its impact, health issues, issues related to urbanization etc.

7.1 Households' demographic information

Majority of the respondent are young with 64.3% falling within the age group of 31-60, the mean age is 43. The age groups below 25 and above 65 are considered more vulnerable in our study because they are less open to any technological changes to improve their adaptive capacity. 93% of the respondents are married and 68% are belongs to nuclear family and only 32% joint family in our survey. The nuclear family heavily depends on its female member. It is found that only 15% of the respondents are illiterate, whereas nearly 75% of them studied up to matriculation. In terms of religion 86% are 'Hindu Koli', rest of them are 'Christian Kolis', mostly from Madh village and Mahim villages. The 'Christian Kolis' are the converted Koli from the time of British rule. Similarly in terms of cast, most of them are falling into special back ward categories.

7.2 Occupation

Majority of the respondents (87.4%) are active fishermen and their major occupation is fishing, and for nearly 98% fishing is the full time occupation, a few of them considered fishing as part time occupation and work in other occupations like, boat making, have small shop or work in private companies. For 11.5% of the respondents, mostly women headed households, those who do not possess any boats, their major occupation is marketing of fish. Net making, fish shed collection which were earlier considered as major fishing allied occupations, now a days because of increase in number of migrants in Mumbai those who are taking up these jobs are thereby not only confined to Koli communities. Similarly the reduction in fish availability and increase in competition is forcing young population to look for other occupations.

7.3 Household amenities and assets

The characteristic of the dwelling/type of house is very much important in defining the vulnerability of households to climate change events like flood, storm and SLR. Fishing villages are situated very close to the sea and very often affected by high storm, cyclones and flood. Although most of the houses in the fishing villages in the survey villages are Pucca (51.6%) and Semi Pucca (48.4%), the houses are very small. And fishermen usually possess huge fishing equipments like; fishing nets, the plastic containers, the oil containers etc. Hence it becomes difficult for them to adjust. Earlier there was lot of open space where they use to keep all those equipments but now days because of urban development, and increase in number of sanities with the increase in their population, they are not getting the place, especially to park their boat.

7.4 Family income

The primary source of income of the households in the villages is fishing as we find fishing is the major occupation of 87% of the household surveyed and for 97% of household fishing is the full time occupation. Only 31% of fishermen families have some other part time income source. The minimum income from fishing is Rs. 40,000 and the highest income is Rs. 2, 50,000 with mean income of Rs. 92, 280 and median income of Rs. 80, 000. In this study household's income below Rs 60,000 are considered as vulnerable. The amount of reference is calculated from Indian poverty line equal to 1,126 rupees per person per month, multiplied by the average household members in fishing villages (4.4), per one year (multiplied by 12), which is equal to 59452.80 (59453) rupees. The discussion with household also reveal that the nature of income is stable/moderate over the years, only 5.5% said their income is increasing, whereas over 19% of the households observed that their income is decreasing over the years.

7.5 Perception of households towards climate change

The climate change problems like; rise in temperature, shift in rainfall pattern are happening more than earlier and as a result of that there is evidence of fish migration, destruction of fish habitat etc. Accordingly the respondents are asked about the climate change and how they view the problems in a five point likert scale. 36.8% respondent rated 'very high' rise in temperature, 45% rated 'high' rise in temperature. Similarly change in rainfall pattern, nearly 49% of the respondents ranked with 'very high'.

7.6 Impacts of climate change on fishing

The impacts like less availability of fish due to climate change, availability at longer distances, and availability of a particular fish which is no longer available due to migration to a different climate zone are explained to fishermen and they are asked to provide their rank in a five point likert scale. The less availability fish ranked 'very high' by 55.5% of the respondents and almost 37% respondents ranked less availability of fish 'high'. Availability of fish in a longer distance is rated 'very high' by 69 respondents and 'high' by 81 respondents. Less availability of a particular fish like (pamphlets) rated 'very high' by 62 respondents and 'high' by 83 respondents. It is found that the knowledge of fishermen on loss of fish habitat and coral reefs is very low, though they relate it to their observations on fish moving from nearer place to further deep into the sea.

7.7 Health Issues

Health is an important socio-economic aspect for the fishery based livelihood. The Koliwadas are very congested and there is little open space left in that area. The slum like place are always exposed to the diseases like malaria, dengue etc. The change in climate also one of the major reasons for increasing health risk in fishing villages. Malaria and Dengue are the frequent diseases which are ranked 'very high' and 'high' by majority of the respondents. More than 80% respondents observed that the frequency of these diseases has increased over the years. Men are more exposed to these diseases rather than women, and children in the family.

7.8 Other Social Indicators

The respondents are asked about other social well beings like; whether they are sending their children to the school. Although most of them (78%) send their children to school, 52.20% of the respondents involve their children in fishing and related activities. Almost all respondents having ration cards, however they are not happy with the benefits the government provides them as there is lot of irregularities in it. 83.50% fishermen said they are getting subsidies in terms of buying fishing equipments like fuel, ice etc. However, not all the fishermen are getting this benefits and it depends upon functioning of fishing societies. Most of the fishermen 95.6% replied that they have insurance; again there are various types of insurance scheme for boat as well as health and life. Fishermen often complained that they get only benefit of insurance in case of complete damage of boat. Partial damages are not considered and therefore some of the fishermen are not interested to bear the burden of insurance.

There is provision of training by government for fishermen. A training institute is located at Versova village that provides training certificates which is required while applying for loan for building boats. However fishermen are not getting proper training, earlier the Institute used to provide a diploma course. Recently due to increase in the fee of course and because the institute doesn't provide any practical training, fishermen are not much interested though they want to know more about how to catch the new varieties of fish, which has more value at international market etc. The government also provides early warning to fishermen, and information regarding wind pattern, cyclone in advance. The coast guard also provides securities from Mafia. However, some fishermen revealed that they are often harassed by the police. Governments also include fishermen in the decision of building any sea link road or sea walls. However fishermen are provided little compensation.

8. Estimation of vulnerability indicators

The vulnerability indicators are developed with the help of weights assigned by experts as well as the primary data collected through field survey. The survey questionnaires as well as data are of different scales and in order to assess over all vulnerability it is required to transform all the data into a uniform scale (0, 1). Therefore different value functions are used. The value functions reflects that vulnerability is higher as adaptive capacity decreases and sensitivity increases, a value of 1 indicates highest level of vulnerability whereas a value of 0 indicates the worst performance (Ekin and Tapia, 2008; Beinat, 1997).

8.1 Results and Discussions

After doing normalization, it is possible to calculate vulnerability levels of the household in the fishing villages. The derived vulnerability scores can also be compared with the score and weights given by experts. The average vulnerability score for the villages surveyed is 0.65, and Madh village is found to be more vulnerable with the highest vulnerability scores of 0.67.

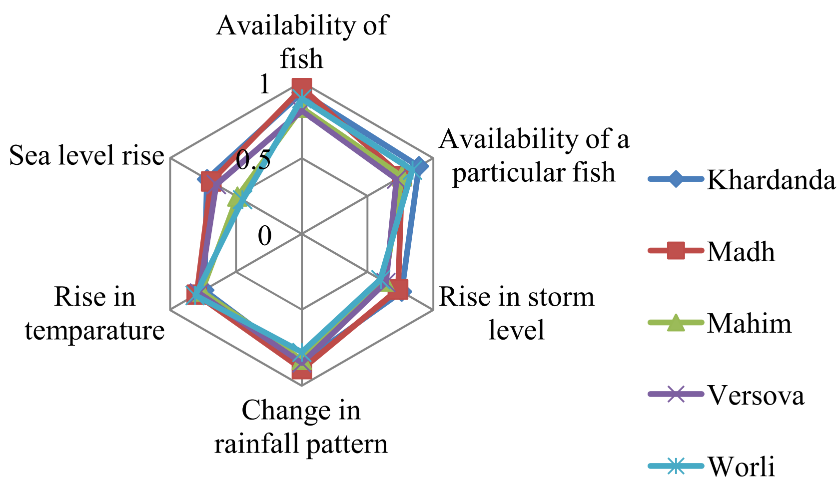
Mahim village has the vulnerability score of 0.58. Similarly the average sensitivity score is 0.81 and average adaptive capacity score is 0.40.

Table 5: Adaptive capacity, Sensitivity and Vulnerability scores for survey villages

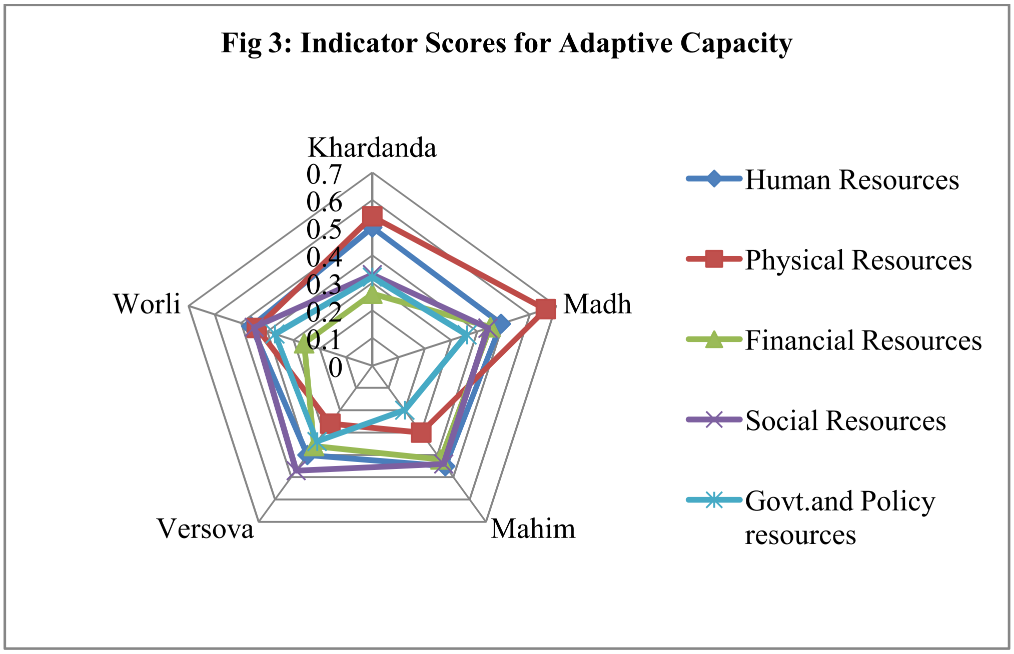
Village	Vulnerability scores	Sensitivity Scores	Adaptive capacity scores
Khardanda	0.61	0.82	0.39
Madh	0.67	0.85	0.48
Mahim	0.58	0.8	0.36
Versova	0.59	0.8	0.37
Worli	0.65	0.81	0.4

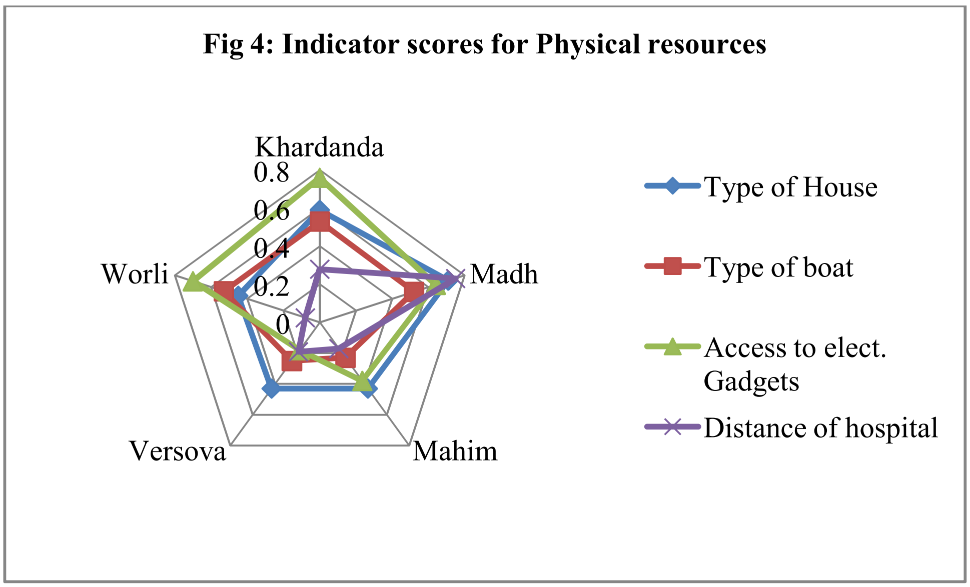
Indicator scores for perceived variability and change are presented in the following figure. The scores for sea level rise are low in all the villages. Whereas less availability of fish is close to 1,

Fig 2: Indicator scores for perceived variability and change



The indicators under adaptive capacity are divided into five categories bases on five types of resources. The following figure shows the scores of these resources for fishing villages. The scores are very high under physical resources, human and financial resources for Madh village indicating a high vulnerability.



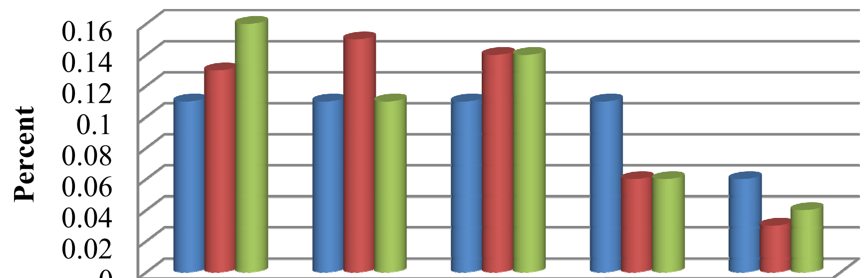


In the above figure under physical resources, all the indicators, type of house, type of boat, access to electronic gadgets and distance to hospital are high for Village Madh showing low adaptive capacity and high vulnerability. On the other hand, in terms of access to electronic gadgets Versova has a high adaptive capacity. Similarly Mahim also possess high adaptive capacity in terms of physical resources. But the scores for type of house are high indicating less adaptive capacity and high vulnerability for Mahim village.

8.2 Comparing Vulnerability Scores with Weighted Scores

The weights given by experts towards various indicators of sensitivity and adaptive capacity are analyzed and compared. The following figure shows weights given by three experts towards five types of indicators of adaptive capacity. The weight given by expert-1 towards social indicator is high in comparison to other experts. And that depends on the expert knowledge and his/her area of work.

Fig 5:Weighted scores for indicators of adaptive capacity



	Human Resources	Physical Resources	Financial Resources	Social Resources	Govt.and Policy resources
Exp-1	0.11	0.11	0.11	0.11	0.06
Exp-2	0.13	0.15	0.14	0.06	0.03
Exp-3	0.16	0.11	0.14	0.06	0.04

8.3 Experts consistency level

Consistency of a judgment implies, if A is preferred to B, and B is preferred to C than A must be preferred to C. Human judgments are never consistence, according to Saaty a 10% inconsistency level is acceptable. The consistency level for all the comparisons by experts are estimate. Some of the comparisons are found consistence with a value of 10 or less. Others are just above 10% level and can considered as good estimation. Few comparisons are also found to be inconsistence with scoring high. The method of this consistency development is taken from Saaty (1980).

9. Conclusion and Policy Implications

The major theoretical implications derived by the study relate to vulnerability assessment at community level. The derived vulnerability scores can be very useful in considering various policy measures in fishing villages in combating with the problem of climate change. The major policy implications brought out by the study are the need for the improvement of education systems at community level, encouraging small scale fishermen by providing subsidies, providing sufficient training to fishermen to effectively adapt the changing fishing practices and climate.

Major Findings

- The vulnerability indicators derived shows Madh and Worli are more vulnerable compare to other villages. The physical resources, financial resources and government policy resources contribute more towards the vulnerability of these two villages.
- Although government provides various help to fishermen in terms of subsidies, insurance, early warning, safety at sea, and ration card. Some villages especially small scale fishermen said the benefits many of the time don't reach to them.
- The decision of government building sea link road and proposed coastal road linkage progamme have substantial affect on fishing livelihood. However, fishermen are not getting enough compensation particularly when the catch is low like agricultural farmers get during a fail in monsoon season.
- The government also has limited role on marketing of fish, fishermen are often exploited by middlemen. The entry of migrants into marketing of fish also affecting the Koli women, those who are traditionally involved in marketing activities.
- Fishermen want their children to go for higher study and look for other jobs, however there is limited support from government towards this.
- It is also found that there is not much help from NGOs and other non-governmental organization towards the development of fishing communities.

15.2 Adaptation Measures

Fishing communities are taking a number of adaptation measures to overcome climate change problems and to maximize their profit.

- Among such measures now a day fishermen are fishing in a group, they are sharing information on fish availability among themselves while fishing in the dip water, and weather related information among each other to catch more fish and to avoid the problem of climate events like cyclones, high tides, heavy rainfall.
- Fishermen are fishing for more days in the sea and able to send their fish catch for marketing by one boat sharing among each other. This helps them in spending more time in the sea and decreasing their cost of travel.
- Fishermen are catching other fish which were not targeted earlier.
- Fishermen are not catching juvenile fish; they are using different nets for catching different fish.

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