Livelihood Vulnerability of Fishery-based Communities in Contextof Climate Change : Insights From and Around Selective Fishing Groundsof South 24 Parganas, West Bengal

ABSTRACT

The 4th Assessment Reports prepared by the Intergovernmental Panel on Climate Change (IPCC) in 2007 reported serious concerns which directly affect the livelihoods of millions of coastal habitants and fishing communities. This study mainly concentrates on the awareness regarding the climate variability and vulnerability exposed by climate change on the marine fishing communities based on their: Socio-Demographic Profile;Livelihood strategies; Social Networks; Health; Water; Natural disasters and Climate Variability and Knowledge and Skills, which are divided into three main components of vulnerability (IPCC): Exposure, Sensitivity and Adaptive Capacity. Here, we have chosen the three major functioning fishing harbours of this district are Lakshmipur Abad of Namkhana, Kalinagar of Kakdwip and Sultanpur of Diamond Harbour with their respective fish landing centers. The primary data used is based on a survey of 150 householdof fishing communities and for secondary data available publications were accessed.

The study reveals that the most important climate-related elements of exposure are the storms and cyclones. We have also found that studied villages are highly populated and competing for limited resources, furthermore lack of economic opportunities like agriculture in coastal areas making these communities already vulnerable along withhigher sensitivity and lower adaptive capacity combine to create higher vulnerability.

Key Words: *Fishing communities, Vulnerability,Sensitivity, Adaptation, Livelihood*

1. INTRODUCTION

The significance of marine capture fishery sector has very important roles for food supply, food security and income generation in India.West Bengal secures a second position in national fish production with about 2945941 of marine fish-folk population contributing to an export value of 1825.12 crore hence the threats of climate change on marine fish production and on the structure of fishing livelihoods comes out to be significant.

Climate change has both long term and short term impacts and are effecting the livelihoods in the agricultural sector, fisheries, forestry's, marine life and it will eventually create risk for poverty and food security and income generations [1]. Assessment Reports of IPCC, 2007 shows the coastal communities inparticular, small-scale fishing communities in developing countries, which constitute 90% fishery-dependent people [2], to experience the complex and vulnerable effects of climate change both in direct and indirect ways.The fisheries sector, which supports livelihoods of 660–820 million people [3], is considered amongst the worst affected by climate change [4]. Coastal communities face several climatic shocks and stresses in the forms of sea level rise, higher

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temperatures, altered precipitation patterns, enhanced monsoon precipitation and run-off, potentially reduced dry season precipitation; increase in cyclone is projected to aggravate this situation [5] and alsointerrupting fishing operations and land-based infrastructures of the region [6].

Livelihood security especially in developing countries like India, is the ultimate concern to face the climate change at the community level. As a matter of fact, local communities are already reporting the effects of variations in climate that tend to affect the poorest and most vulnerable communities [7]. To address the impacts, adaptation is widely recognised as an important response strategy along with mitigation [8, 9, 10]. So here the study was conducted to assess the vulnerability of fishery-based livelihoods to the impacts of climate change in fishing communities and their households of adjacent villages to the three major fishing harbours as well as major fish landing centres of South 24 Parganas.

2. AIMS AND OBJECTIVES OF THE STUDY

The study mainly focuses to –

1. Assess the knowledge and perception of the fishing communities on the trends of climate change and variability.
2. Examine the vulnerability of the fishery-based livelihoods to the impacts of climate change.

3. MATERIAL AND METHODS

3.1. Study Area

Figure 1 – Location of the Study Area

The fishing communities residing in adjacent villages to the Fishing Harbours as well as major fish landing centres of South 24 Parganas. The three major functioning fishing harbours of this district are situated at Diamond Harbour, Kakdwip and Namkhana with their respective fish landing centers. The purpose of selecting adjacent areas to the fishing harbours is to get a fruitful community response as a huge concentration of fisher folk population engaged with this harbours has been found flocking in thereby. Among the selected fishing blocks Lakshmipur Abad of Namkhana, Kalinagar of Kakdwip and Sultanpur of Diamond Harbour. I have chosen them for their highest invovelment in fishing functionalities and population density.

3.2. Data Source, Sampling, and Sample Size

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Data was collected both from primary and secondary sources. Primary data was collected from the fishermen.The secondary data was collected from official records of the Indian Meteorological Department (IMD), published reports of similar projects, journals and literatures.The sample for the present study comprises of 150, 50 from each of the study sites, whowere involved in fishing as their primary occupation, following a simple random samplingtechnique. A face to face interview schedule and Focus Group Discussions (FGD) were used as a tool for primary data collection. The data is beingmostly analyzed in Microsoft Excel. The analysis and inferences were finally carried out through textual and tabular formats followed by the description of the study results.

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3.3. Understanding and Assessing Livelihood Vulnerability

Vulnerability of climate change senses as "a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" [2]. The current study has applied a vulnerability approach which incorporates by the IPCC, 2007: "vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity". In this concept, the components, 'exposure' and 'sensitivity' create potential impacts and increase vulnerability, while 'adaptive capacity' decreases it. So, the three main components that need to be considered in Livelihood Vulnerability-IPCC are Exposure, Sensitivity and Adaptive Capacity. This study considered these three as major components and designed the discussions in Table-1 categorizing these three into further eight sub-components.

Table 1 - IPCC contributing factors to Vulnerability

IPCC contributing factors to Vulnerability	***Major Components***
Exposure	i) Natural disaster and Climate Variability
Sensitivity	i) Food
	ii) Water
	iii) Livelihood strategies
Adaptive Capacity	i) Socio-demographic profile
	ii) Health
	iii) Knowledge and Technical Skills
	iv) Social Network and Technologies

4. RESULT AND DISCUSSIONS

4.1 Perception and Awareness on Climate Change

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Perception validation holds important criteria when issues dealt with human intimacy. In the study the surveyed community confirm their experiences of certain changes and abnormalities in the climatic behaviour but are found totally ignorant of the term 'Climate Change' as a global concern.

Table 2 - Respondents' awareness about phenomena related to climate change (N=150)

Sl. No	*Phenomenon related to climate change*	*Fully aware*	*Somewhat aware*	*Not aware at all*	*Mean*
1	Increase in sea level	91	28	31	2.4
2	Increase in the number of cyclone per year	33	85	32	2.0
3	Rise in both day and night temperature	129	20	01	2.9
4	Phenomenon of increased drought and flood	58	51	41	2.1
5	Increased variability in rainfall	71	32	47	2.2
6	Increase sea surface temperature	01	13	136	1.1

Source –Compiled by the authors from field survey

Comment [A20]: Source: Field survey (year)

On what they put on maximum strength is on increased temperature, rise in the sea level and on changing nature of rainfall patterns. The mean values of **(**Table-2**)**ofthese three categories of 2.9, 2.4 and 2.2 respectively affirm in favour of their responses.

Table 3 - Distribution of respondents on perception of climate change consequences (N=150)

Sl. No	*Statement*	*VL*	*SL*	*UD*	*SU*	*VU*	*Mean score*
1	There will be increase in frequency of storm	38	68	33	8	3	3.9
2	There will be increase in frequency of flood	59	62	18	5	6	4.1
3	There will be heavy inundation of land	75	28	7	13	27	3.7
4	There will be heavy reduction in fish production	98	48	0	4	0	4.6
5	There will be reduction in number of fish species	98	52	0	0	0	4.7
6	livelihood will be affected	96	27	23	3	1	4.4
7	Standard of living will decrease	93	40	12	3	2	4.5
8	Starvation and food shortage will occur	0	17	83	36	14	2.7
9	chance of suffering from serious disease	109	13	22	4	2	4.5
10	Impact on biodiversity and coastal ecosystem	0	123	19	7	1	3.8

11	Increase of sea water will lower the availability of fresh water	74	42	31	2	1	4.2

{VL: Very Likely; SL: Somewhat Likely; U: Undecided; SU: Somewhat Unlikely; and VU: Very Unlikely} ***[Source –Compiled by the authors from field survey]***

Comment [A21]: Source: Field survey (year)

4.2. Assessment of consequences of Climate Change: The respondents expressed their perceived consequences as very to somewhat likely as evident by the obtained mean score of above 4 in almost all the cases (Table-3). That the reduction in number of fish species which effect on standard of living of fishermen and their various diseases had mean scores above 4.5, which signified their perceived occurrence as very likely to somewhat unlikely. The findings revealed that there are inherent perceived risks and apprehensions among the respondents about the consequences of climate change.

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Assessment of Livelihood Vulnerability [IPCC,2007 Framework Approach]

The vulnerability approach is constructed on the notion that vulnerability is a function of exposure to climate change and variability; sensitivity to the impacts of that exposure; and the ability to adapt to ongoing and future changes [11].

$$(V) = f(e+s-ac)$$

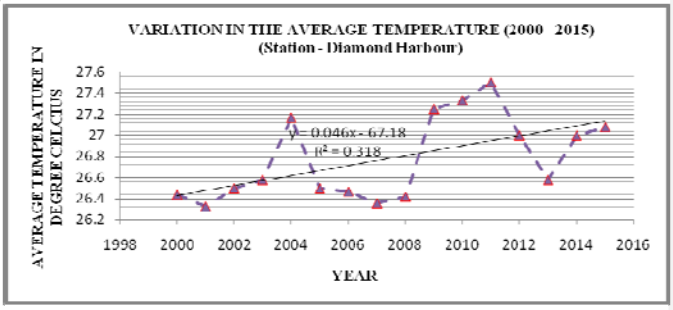
[where, V = vulnerability; e = exposure; s = sensitivity; ac = adaptive capacity]

4.2.1. EXPOSURE

Trend of Annual Temperature: The temperature dataset of (2000-2015) of Diamond Harbour Meteorological Station shows an observable rise in the average temperature that is predicted to effect the overall physical and socio-economic processes of this region. The data reveals a 0.73^0c increase in the average daily temperature. Two marked peaks in average temperature has been observed in 2004 and 2011 with the present increasing trend since 2013.

Figure 2 – Variation in the average temperature (2000 – 2015)

Station – Diamond Harbour

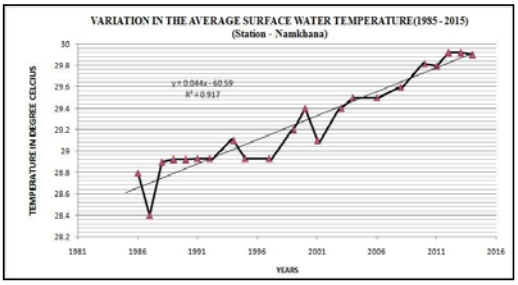


Source – Indian Meteorological Department, Alipore

While going through the study another revealing observation showed a faster increase in the average minimum temperature than the maximum resulting in a gradual decrease in diurnal range. This changing temperaturetrend is slowly but seriously becoming more of a concern and needed to be immediately mitigated.

Mean Surface Water Temperature: The decadal study of the Mean surface water temperature in the study sites has shown significant rising trends for the period of (1985-2016).

Figure 3 and Figure 4 - Trend in Surface Water Temperature at Namkhana and Diamond Harbour (1985-2016)



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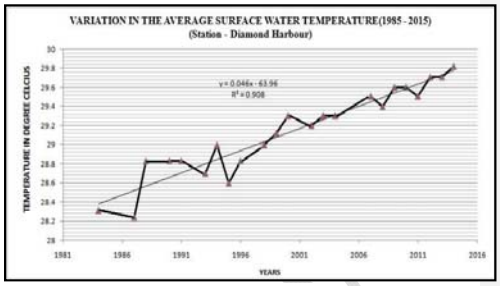
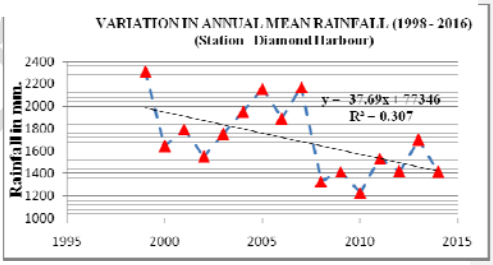


Figure 4

Source – Chatterjee et al.,2015

The Surface Water Temperature for Namkhana have varied 1.15^0c in 30 years with a yearly increase of $.04^0$ c, while Diamond Harbour reveals 1.6^0c increase with yearly average of $.05^0$c.increase [12]. This rising trend of sea surface temperature is directly related with the increased frequency and severity of depressions and cyclonic storms which clearly indicates the higher susceptibility of the fishing communities to these hazards in particular as in concern to their habitat exposure.

Figure 5 – Variation in Annual Mean Rainfall (1998-2016)
Station – Diamond Harbour



Source – Indian Meteorological Department, Alipore

Annual Mean Rainfall: The Study site receives rain mainly from the South-Western monsoon. Though the above dataset over a period of 1998-2016 reveals a declining trend of 46.11mm in the mean annual rainfall, studies show an increase in Post-Monsoonal rainfall over the Northern Bay of Bengal. This localized heavy downpour with its associated adverse effects and erratic nature of rainfall is the main concern of recent climate variability. This leave with no clue for the fishermen in understanding and coping with this unsystematic nature and adapting against its adverse effect.

Cyclonic Disturbances: The coastal and estuarine blocks of South 24 Parganas has been categorized as highly prone (Very High, P1 Zone) coastal area with high intensity of flood (FL Zone) in cyclone proneness and flooding intensity respectively **[13, 14].**The first five year (2000-2005) in a 15 year trend reveals a below average value of 3.8 disturbances / year but after 2006 up to 2008 there has been considerable increase in the occurrences of such system.

Table 4: Frequency of Different Cyclonic Parameter over Northern Bay of Bengal

Sl. No	***Parameters***	***Years***																
		2000	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016****
1	Depression (31-49 km/hr)	1	1	-	2	2	2	6	1	2	-	1	2	-	4	2	2	1
2	Deep Depression (50-61km/hr)	-	-	-	1	1	1	2	3	1	2	1	2	1	-	1	-	2
3	Cyclonic Storm (62-88km/hr)	1	1	1	-	-	3	3	2	3	1	-	1	-	2	-	2	1
4	Severe Cyclonic Storm (89-118km/hr)	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-
5	Extreme Severe Cyclone (119-221km/hr)	-	-	-	1	-	-	-	1	-	-	-	-	-	1	-	-	-
6	***Total Disturbances***	2	2	2	4	4	6	11	7	7	4	2	5	1	7	3	4	4

Source – Compiled by the authors from e-Atlas-IMD:Tracks of Cyclones and Depressions in the Bay of Bengal and Arabian Sea * upto Augut 2016

However, from (2009-2012) a decline in the occurrences again revived to an increasing trend in the last 3 years. Though the average number of disturbances during the last 5 years has reduced to 4 the frequency of severe storms and intensity increased remarkably.The cyclones bring high wind, heavy rain and storm surge causing embankment failure anddevastation through saline water inundation. The floods have its effect on the socio economic livelihoods of the areas [13].

4.2.1.5. Land Erosion: Several studies show the local sea level rise in Sagar Island in Diamond Harbour to be 5.22 mm/year and 3.14 mm/year, respectively [15, 16]. Both these values are much higher than the Indian national average rise in sea level of 1.88 mm/year. This estimated rise in sea level is likely to affect Namkhana situated along the Hugli estuary falls betweenSagar and Diamond Harbour and it eventually exhibit 4.37% of land loss and inundation in a three decadal window gap.

Table 5: Trend of Land Erosion and Inundation

Namkhana	
Years	***Land loss and inundation (sq km)***
1979	151.63
1989	150.20
2001	147.30
2011	145.00

Source – Chatterjee et al.,2015

4.2.2. SENSITIVITY

At the local level exposure and sensitivity are almost inseparable and it is challenging to characterise them [17]. Sensitivity in this context of climate induced vulnerability is the degree to which a livelihood system is affected by or responsive to climate stimuli (note that sensitivity includes responsiveness to both problematic stimuli and beneficial stimuli [2].Hence when analyzed the sensitiveness of the study areas we focused on three major components i.e., Water, Food and Livelihood Strategies and broke each of them in sub components for the detailing.

Table 6: Assessment of sensitivity of the community towards climate change

SENSITIVITY	**Food**	Average per head nutrients uptake from sea food (grms / week)	440±219.74grams / week
		Average no. of months households face challenges in getting sea food	2.73± 1.48 months
		Percentage of households can afford getting animal protein other than seafood	45 %
	Water	Percentage of households use unsafe source of drinking water (Tap & Tube well – Safe ; Pond & River – Unsafe)	2 %
		Percentage of households face trouble in accessing drinking and regular use water	78 %
		Percentage of households do not get a consistent supply of fresh water	58%
		Average time from households to water source	13.3±5.87 minutes
	Livelihood Strategies	Percentage of households having Kutcha and Semi- Pucca house	82%
		Percentage of households living in rented houses	31%
		Percentage of households without natural capital	94%

		Percentage of households without livestock	73%
		Percentage of households without financial capital	97%
		Fishery-based livelihood diversification index	0.42
		Percentage of households without fishing boat and net ownership	83%

Source: Field survey

The first major component **Food** elaborated that though belonging in the fishing community the average consumption of sea food is just 440±219.74 grams per head a week and only 45% of the community can afford having other animal protein than sea food. The challenges in their profession are found prominent as an average of 2.73± 1.48 months in a year when attaining food becomes a challenge for them. Households are able to get consistent access to food all-year where persons are involved with multiple income sources or are engaged with some secondary occupation and like agriculture.

The next major component Water along with its sub components revealsabout 78% of the households face troubles in accessing watermainly in terms of its constant supply and far-off sources for their safe drinking and household uses. 58% household claim not to have a consistent water supply and to collect water women and girls are customarily charged travelling over long distances. Households states to walk an average distance of 13±5.87minutes to access water from wells and community pumps.Because of these water challenges, 2% of respondents access water through natural and unsafe water sources. These households increase the susceptibility to waterborne diseases.

The third and one of the most important component to analyse the sensitivity proneness is to go through the livelihood strategies where we found about 82% of the houses are semi-pucca or kutcha and about 31% of the households doesn't own a house and stay rented. The quality of houses was taken as an indicator to have an understanding of the responsiveness of the community against the vulnerability patterns as an improved level of house condition lowers the intensity of vulnerability. Most of the houses are thatched or have asbestos shades with mud or brick walls and holds the obvious chances to get destroyed inextreme weather events. Results show the only capital they possess are the livestock. 27% of the households cultivate livestock and 94% and 97% of the households run out of any type of natural and financial capital. The households with livestock assets stated of their incapability in extending their livestock due to their low income coverage. Inadequate financial capital such as jewellery, financial savings and deposits, makes them helpless in their coping mechanisms and more vulnerable in time of disasters. Almost 83% of the total households doesn't have their ownership on fishing boats and nets, they live on a lease partnership for their essential equipments needed for fishing. The lack of boats and nets limits the households' resilience to climate change, makes them moresensitive and hencerequires them toadopt more climate-sensitive strategies. An attempt has made to calculate the Livelihood diversity of the community for a more detailed understanding of their sensitiveness where the average Livelihood Diversification index value came out at 0.42 when inversed i.e. vulnerability increases as the index value increases. Only 11 households out of 150 are found to have secondary income along with fishing. Most of the households have the diversification index value of 0.5 that indicates to only one secondary source of income. Most in the case it iseither a teeny-weeny store with regular need groceries runs by the

females or the aged ones in the households or else it is the young members of the households generally the school drop-out teen boys who run rickshaws or vans and totosfor this alternate income. The study reveals only in three cases that the maximum value of this inversed livelihood diversification index is 0.25 which denotes the prevalence of three secondary income sources at the same time.

4.2.3. ADAPTIVE CAPACITY

'Adaptive capacity' refers to the potential or capability of a system to adjust toclimate change, including climate variability and extremes, so as to moderatepotential damages, to take advantage of opportunities or to cope with consequences[18]. So in this sense, if adaptive capacity increases it reduces vulnerabilities.

Table 7: Assessment of Adaptive capacity of the community towards climate change

ADAPTIVE CAPACITY	**Socio – Demographic Profile**	Dependency Ratio	0.073
		Percentage of female headed households	10.6
		Average age of the head of the households	65.93 ±4.51 yrs
		Percentage of households with persons having disability and ill mental health	09
		Percentage of households with heads without formal education	81.3
		Average highest years of schooling among the house members	8.4± 3.03 yrs
	Health	Percentage of households having unfit workforce	30
		Percentage of households not availing Government health facilities	77
		Percentage of households experienced health damage due to natural disaster in past	59
	Knowledge and Technical Skills	Average years of experience of the household heads in fishery based occupation	32.26±5.65 yrs
		Percentage of households follow conventional and non-machinery methods in fishing based occupations	95
		Percentage of households do not posses any training in disaster	100

		management	
	Connections with social networks and Technologies	Percentage of households without adequate access to banking facilities	25
		Percentage of households have taken credit from formal sources	32
		Percentage of households have taken credit from non-formal sources	51
		Percentage of households having outstanding loan in last 5 years	51
		Percentage of households are in no connection or are non-recipient of any financial and technological innovations and amenities	02
		Percentage of households having electricity connections in their homes	89
		Percentage of households posses and get information from television	87
		Percentage of households uses radio	17
		Percentage of households have access to internet facilities	12
		Percentage of households are in regular use with walky-talky	06

Source: Field survey

On the Adaptive Capacity head we have classified it into four main components with necessary sub-components to describe them. On analyzing the **socio-demographic profile**, as one of the major components we found the dependency ratio touching 0.073 and implies to a demographic position that has quite a higher dependency on the working class. A higher dependency indicates to low per capita income and marks a community fragile and vulnerable against all odds. This can reduce one's resilience to climate change. 16 households i.e. almost 10.6% of the total surveyed heads came out as femalemale-headed households are in a better positionto cope with or adapt to climate change than female-headed households because female headed household have limited access to livelihood capital assets and strategies [19, 20,21, 22]. The community has been found with a high dominance of aged head, the average age of which being 65.93 ±4.51 years. The average reported age of the female household heads was 54.8± 7.81 years.09% ofhouseholds reported to have at least one person that requires daily care because of old age, disability or mentalhealth challenges. Households with orphans and persons requiring daycare place extra stress, and may reduce their resilience in coping and adapting to climate stresses.About 81.3% of the household heads are found to have lack in formal education. Even an average of 8.4±3.03 year is being reported as the highest schooling years of the community. This clearly implies that the community is being following this profession

through generations learning from the experience from their elders. A higher level of education can affect lifetime earnings of a household but on the other hand limited education can constrain its ability to understand disaster warning information and access recovery information [23].These indicators actually help in understanding the probability of an endangered community to go against all the odds and overcome the same.

Households with greater human capital such as a higher number available for the workforce with better **health**[18, 19] have a greater level of adaptive capacity. Here 30% of the householdsreported to have unfit workforce. 59% of the surveyed households reported with health damage due to natural disaster in past. Most of the households (about 77%) are casual or ignorant or have disregard for Governmental health benefits and facilities. Hence through analyzing the information collected from these four major components along with their sub-components the study founds the community vulnerable and proves its probability of being unrealistic in its survival through the changes in the climate.

The third component that was considered for constructing human capital was **knowledge and skills.**Under this category, the community turns out to be highly experienced in fishing related activities. Survey founds the households'posses an average of 32.26±5.65 years of experience in the fishing sphere.Of the total surveyed households 95% detailed of have using conventional and non-machinery tools and methods of fishing and no one found coming up with any type of practical training for fruitful coping up with disasters. It was found from the personal interviews that no one in the study area 'never' received any training on climate preparedness or awareness.

25% of the respondents did not have adequate banking facilities which show limited connections to banks. It should be mentioned that banks are not frequent in the areas and banking facilities are only centered at Sultanpur in Diamond harbour. The community proves their requirement for finance as 32% and 51% of the households have taken credit from formal and non-formal sources respectively and 51% among them are running with outstanding amounts. Among the non-institutional sources professional money lenders, trader and relatives, neighbours and friendshad the major share. Thus the practice of money lending found to be quite popular in the study areas and to a large extent based on mutual trust andunderstanding between lender and borrower than on formal documented agreements. 14 of the 16 female headed households borrowed from relatives andneighbourswhile 2 from money lenders. None of the female-headed households borrowed from institutional sources. Mostof the households are unaware or showed unwillingness to any type of local governmental help or assistance in cash or in kind. Almost no one (02%) came up with any information and **connections to financial and technological innovations** and assistance relating to the fishing sector.Though 89% of the household have electricity and 87% of them having their own television set, when asked if they are aware of the current climatic behavior totally failed to give any response. They use the television as a media of entertainment. Same is to say for radio too though it is accepted on a lesser note (17%) than of television. Most of the households owns mobiles but reported to lack the internet accessibility as wireless signal strength gets lower connectivity in the interior and remote parts of these villages.

5. Conclusion:

This study attempts to represent climate induced vulnerability of three villages adjacent to the major fishing harbours as well as major fish landing centers of South 24 Parganas. Factors in manifold influenced the livelihood vulnerability of these communities. Climatic variations by whichthey are affected the most are temperature and rainfall while the community's dependence on marine fishing in major to run the livelihoods increases the range of sensitivity. The study concludes the area as extremely vulnerable to climatic hazards. Meteorological data and former experience of respondents also validates the negative impacts of climate on the livelihoods. In general, the villages are highly populated and competing for limited resources. Furthermore, lack of other economic opportunities like agriculture in these coastal areas is making these communities more vulnerable. However it suggests further studies on the adaptation options and coping mechanism to make thefisher folk adapted with the changes in climate.

6. References:

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