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Impact of Cyclone on Livelihood of Coastal People: A Study of Galachipa Upazila, Patuakhali District

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Abstract
The present research involves the findings of the studies on the impacts of cyclonic storms on the livelihood of coastal communities in Galachipa Upazila. Moreover, the perception of the people on the adverse effects of Cyclone SIDR is related to climate change to a great extent. The results of the livelihood vulnerability index (LVI) and Livelihood Vulnerability Index –Intergovernmental Panel on Climate Change (LVI-IPCC) show that Galachipa Upazila is modestly vulnerable to Cyclone. Based on demographics, diversity of livelihood strategies and social network strength of households study finds that Galachipa Upazila has a moderate capacity score. Moreover, the study finds that people who are dependent solely on agriculture and livestock of Galachipa Upazila are more vulnerable to climate change. Therefore, community adaptive capacity is fairly good for being quickly adaptive to any changing condition. The Education status of the study area also seemed to be better than in the rest. However, accounting for the current state of health as well as food security in the study area is moderately sensitive and water implies higher sensitivity to climate change impact. Galachipa Upazila has a higher exposure score. Natural Disaster and Climate Variability seemed to have contributed highly to the overall vulnerability. These results have implications for the initiation and implementation of climate change adaptation and household resilience projects by the government, donor agencies, and other related organizations as well as this research might be useful for policymakers, researchers, and further study.

Keywords: Livelihood vulnerability index, Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change, Climate change, Cyclone SIDR

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1.0 Introduction

Tropical cyclones of the Northern Indian Ocean and the Bay of Bengal can be considered the most disastrous and harmful natural calamities in the rim countries of the Bay of Bengal where Bangladesh occupies the northern apex of the Bay.

Due to the country's geographic location, unique natural environment, and tropical monsoon climate condition Bangladesh is more vulnerable to cyclones and storm surges (Paul, 2009a). Bangladesh is one of the most cyclone- prone areas in the world. This catastrophe is causing a huge loss of life, resources, and the natural environment of Bangladesh almost every year. So, people of the coastal areas of Bangladesh are very vulnerable due to living in an extremely dynamic estuarine environment as well as facing many natural threats. Approximately, 12-13 depressions are created each year and at least one strong cyclone hits Bangladesh every year (Mooley, 1980; Paul, 2009a, Ahmed 2005). Almost every year one or more cyclones hitting coastal Bangladesh are nothing new, but in recent years there have been some significant changes in their occurrences. The incidence of cyclones has increased in the Bay of Bengal which is considered to be an important cause of Global warming (IPCC, 2001, Ahmed 2005). Most of the Cyclones form in the Bay of Bengal between May to December with the highest frequency in November followed by October (Rahaman et al., 2012). Thus about 183 severe cyclones with a wind speed of more than 87 kph were formed in the Bay of Bengal from 1891 to 2008 (Alam and Collins, 2010). A number of catastrophic cyclones hit Bangladesh in 1822, 1876, 1961, 1965, 1970, and 1991 (Wisner et al., 2004). After the cyclone of 1970 and 1991, SIDR 2007 was the worst storm in the history of Bangladesh. Compared to the cyclones in 1970 and 1991, the death toll in 2007 was relatively small approximately 3,406 people died and 55,000 were injured, with more than 1,000 missing and estimated damage of USD 1.6 billion (Paul, 2009a).

The Livelihoods of the coastal population are highly dependent on the nature connected with agriculture, fishery, forestry and salt farming etc. Therefore, the rising trend of cyclones will unquestionably affect the livelihoods of vulnerable populations living in the lowest coasta of Bangladesh (Mian, 2005). Galachipa Upazila is the southern-most Upazila in Bangladesh and is approximately 219 km away from Dhaka capital city of Bangladesh is located on the shoreline of the Bay of Bengal extremely vulnerable to coastal cyclones. Therefore, natural hazards

such as cyclones, tidal surges, high winds, as well as unpredictable rainfall are reoccurring threats in Galachipa. The people of Galachipa Upazila are mostly dependent on agriculture, farming as well as natural resources for their livelihood. So occupation of the local people of Galachipa Upazila is closely related to the environment. So, any disaster badly affects their lives as well as their livelihood system. Therefore, the study was carried out in the southernmost area in Bangladesh Galachipa Upazila to reveal the impacts of cyclonic storms on the livelihood of coastal people of Southern Bangladesh. Natural disasters cannot be completely prevented or controlled but the amount of damage can be reduced.

2.0 Objectives of The Study

The main objective of this research is to assess the vulnerability of the people and land to the Cyclonic disasters especially that of SIDR on the inhabitants of the Galachipa region, Patuakhali District, and in the southern part of Bangladesh.

3.0 Profile of Study Area

a. Topography

Galachipa Upazila is situated in Patuakhali District, in the division of Barisal, Bangladesh (Figure 1) was selected as a target area for this study as a result of its significantly liable to natural hazards like cyclones, tidal surges, high winds, and erratic rainfall. The area of Galachipa Upazila is 1267.89 sq km, located between 21°46' and 22°05' north latitudes and between 91°15' and 90°37' east longitudes (Banglapedia, 2021). It is bounded by the Bay of Bengal to the south and Char Kukri Mukri to the east and by the Kalapara Upazila and Ramnabad channel to the west as well as Chalitabunia river, Agunmukha river, Galachipa union, and Char Biswas to the north.

b. Demographics and Administration

Galachipa has a population of 238681; male 119189, female 119492 as well as an Indigenous community such as Rakhine belong to this Upazila. Galachipa has an average literacy rate of 52.84%; males 46.5%, and females 39.1% (Banglapedia, 2021). In March 2011, part of the Upazila was separated to make the new Rangabali Upazila. Galachipa has 1 municipality, 12 Unions, and 149 villages

c. Climate

Galachipa enjoys a tropical monsoon climate. January is the coolest month with temperatures averaging near 26 ºC (78 ºF) and April is the warmest with

temperatures from 33 to 36 ºC (91 to 96 ºF). Maximum rains occur during the monsoon (June-September) and little in winter (November February). In the study area observed the highest rainfall is 579 mm in July and the lowest rainfall is 16 mm in January during the period 2020 (BMD, 2020). Galachipa is subject to devastating cyclones, originating over the Bay of Bengal, within the periods of April to May and September to November often accompanied by surging waves, these storms can cause infinite damage and loss of life in this region.

d. Vegetation Coverage

Coastal vegetation acts as a green belt or Life wall around the coast in protecting the life and resources of the coastal people. So, vegetation density is a very important factor in alleviating storm surges and natural disasters. A Normalized difference vegetation index (NDVI) map of Galachipa Upazila is generated to evaluate the density of vegetation coverage using a Landsat 8 OLI image. This NDVI map of Galachipa Upazila gives us a clear indication that the amount of vegetation coverage in the study area is adequate to combat cyclones as well as other natural disasters. Growing human demand is putting a lot of pressure on the vegetation of the study area. Therefore, it is necessary to take an afforestation program to survive the tidal wave. It is assumed that restoring the forest allows nature to take its course. So, it is better to restore the forest than to afforest it.

e. Livelihood of Local People

Galachipa Upazila the coastal region of Bangladesh offers a diverse range of livelihoods. Most of the people here are related to agricultural activity. But the agricultural sector is facing a serious threat due to climate change as well as frequent cyclonic events. Fishing is a traditional and most popular source of income for people in the study area. Among these shrimp seed collection as well as shrimp cultivation is popular here. Again, people are mostly dependent on forest resources and rivers for their livelihood. Disasters like cyclones and tidal surges seriously affect their life and livelihood severely. For example, disasters like cyclones and tidal surges seriously affect the frequency of daily food intake of the poor people of Galachipa Upazila. The study finds that more than 80% of people who are accustomed to intake at least 3 meals a day under normal conditions are bound to drastically reduce their meals after disasters.

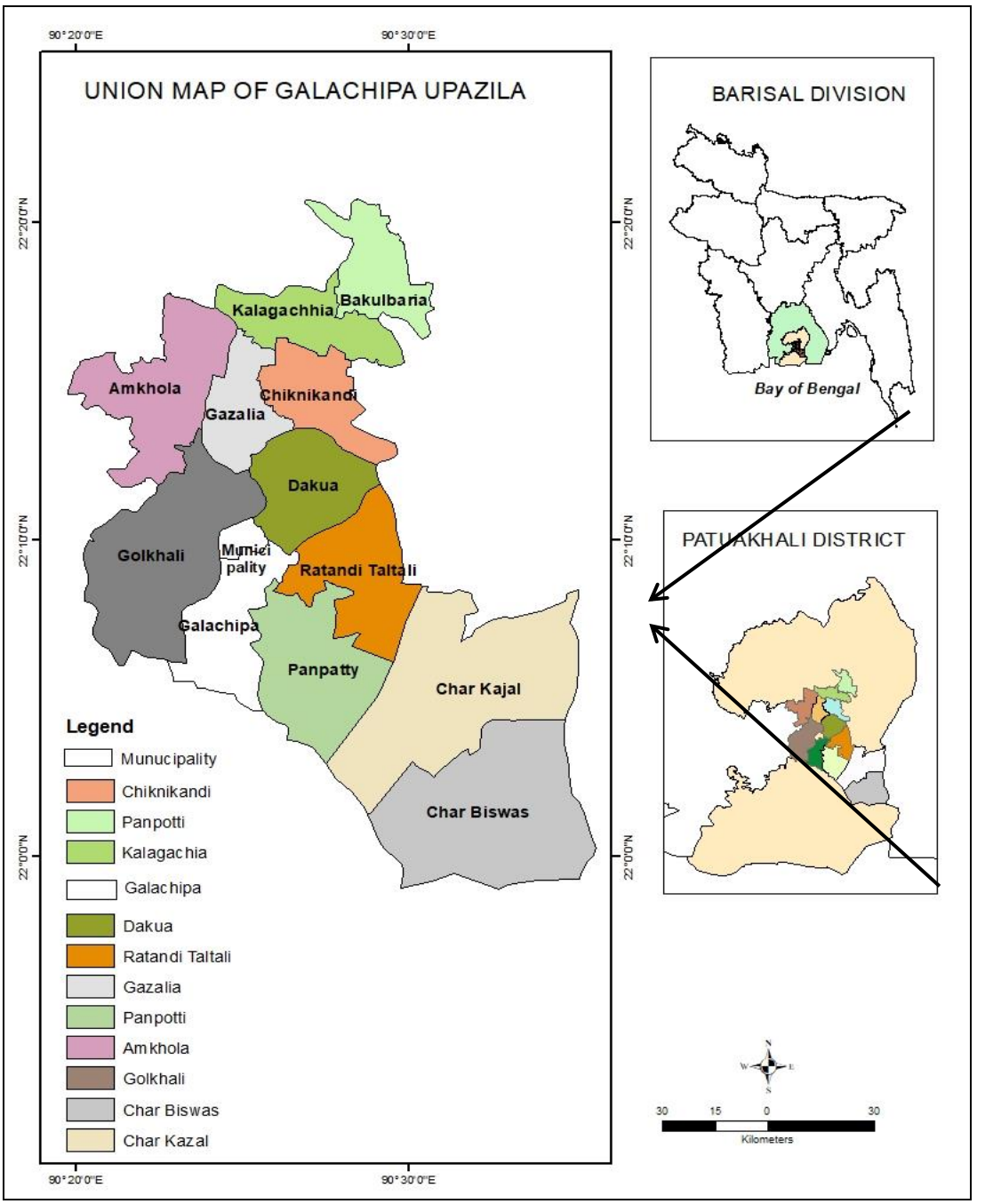


Figure 1: Location of Galachipa Upazila in Bangladesh

4.0 Data Source and Methodology

This study is based on both primary and secondary data which are collected through observation, questionnaire survey, and published documents. The Primary data are based on face to face survey carried out during April-June 2020 period to assess the vulnerability in the livelihood of local people of the Galachipa Upazila. A total of 100 households were chosen among 80054 households of Galachipa Upazila as enumerated in the Population and housing census 2011. The interviews are performed using a semi-structured questionnaire. Both male (89) and female (11) headed households were interviewed. This ensured 95% confidence level with 10% confidence level interval for the interview responses. Secondary data on rainfall and temperature are collected from Bangladesh Meteorological Department for the period 2015-2020 to assess the climate change effects and related vulnerability. This paper has explored the analytical utility of using the livelihood vulnerability index (LVI) developed by Hahn et al., (2009) and Livelihood Vulnerability Index –Intergovernmental Panel on Climate Change (LVI-IPCC) index to reveal the impacts of cyclonic storms on the people of southern Bangladesh. To develop these two indices findings of the investigations are used using appropriate statistical techniques and Microsoft Excel. LVI-IPCC is used as an alternative method to compare the results of the LVI.

4.1 Model 1: LVI Framework Approach

Seven major components make up the LVI index at each major component is composed of several sub-components. The major components used in this study are socio-demographic profile (SDP), Livelihood strategies (LS), social networks (SN), health (H), food (F), water (W), natural disasters, and climate vulnerability (NDCV) (Pandey and Jha 2012). These seven components represent the three factors of vulnerability which are sensitivity, exposure, and adaptive capacity.

Table 1: Relating LVI major components with vulnerability factors

Vulnerability Factors	Major Components
Adaptive Capacity	Socio-demographic Profile Livelihood Strategies Social Network
Sensitivity	Health Food Water
Exposure	Natural Disaster Climate Variability

Source: Hann et al., 2009

The balanced weighted average approach used by Hahn et al., (2009) ensures that each sub-component contributes equally to the overall index even though each major component is comprised of a different `number of sub-components. The measuring scale of each sub-component is different and that is why the following standardizing equation is used to compute the value of each sub-component:

$$Index_x = (X\text{-}Xmin)/ (Xmax\text{-}Xmin)$$

Here, x is the original sub-component; X*min* and X*max* are the minimum and maximum values respectively, for each sub-component (Pandey and Jha 2012, Hahn et al.2009). For example, X may represent the dependency ratio of a household. The variables which are measured in frequencies are converted into percentage; the minimum value is considered 0 and the maximum 100. After standardization of each subcomponent, the values were averaged using the following equation:

$$M = \frac{\sum index(S)}{n}$$

Here, M is one of the major components of LVI [socio-demographic profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W), or Natural Disasters Climate Vulnerability (NDCV)], and s represents the subcomponents that make up each major component and n is the number of subcomponents in each major component.

After calculating the seven major components, they are again averaged using the following equation:

$$LVI = \frac{\sum w \times M}{\sum w}$$

Here, LVI is the livelihood vulnerability index and it equals the weighted average of the seven major components. W is the number of subcomponent in each major component and M is the value of the major component (Hahn et al., 2009). The scale of LVI values ranges from 0-0.2 = Not vulnerable, 0.21-0.4 = Vulnerable/Moderate and 0.41-0.5 = Very vulnerable (Gravitiani 2018).

4.2 Model 2: IPCC Framework Approach

LVI-IPCC incorporated the IPCC vulnerability definition, where classify the nine major components under the three categories of exposure, adaptive capacity, and sensitivity (Hann et al, 2009). In this approach, each major component comprises several sub-components or indicators, as in the standard LVI. Similarly, Equation of LVI were applied to calculate the LVI–IPCC Instead of one weighted average, as in the standard LVI approach which has been calculated as follows

$$Exp_g = \frac{We_1 ND + We_2 CV}{We_1 + We_2}$$

We_1 and We_2 are the weight for natural disasters and climatic variability, respectively, and equal to the number of sub-components. We assumed that the higher the rate of change of the climate variables and the higher the frequency of natural disasters, the higher will be the exposure of households to a changing climate and extremes.

$$Sen_g = \frac{Ws_1 H + Ws_2 F + Ws_3 W}{Ws_1 + Ws_2 + Ws_3}$$

Where, Ws_1, Ws_2, and Ws_3 are the weights for health, food, and water respectively.

$$Adp.cap_g = \frac{Wa_1 SDP + Wa_2 LS + Wa_3 SN}{Wa_1 + Wa_2 + Wa_3}$$

Where, Wa_1, Wa_2 and Wa_3 are the weights for the socio-demographic profile, livelihood strategies and social networks.

The three contributing factors were combined using to calculate the LVI-IPCC.
LVI-LPCCg = (Expg – Adp.cap$_g$) × Sen$_g$

Where, LVI–IPCCg is the LVI for the studied group, which uses the IPCC vulnerability framework. Exp is the exposure score (equivalent to the Natural Disaster and Climate Variability), Sen is the sensitivity score (weighted average of the heath, food, and water) and Adp.cap is the adaptive capacity score (weighted average of the socio-demographic, livelihood strategies, social networks, knowledge, communication, and finance), and. The scale of LVI-IPCC values ranges from -1 – (-0.4) = Not vulnerable, -0.41 – 0.3 = Moderate, and 0.31 – 1 = Very vulnerable (Gravitiani 2018).

5.0 Vulnerability Results of Galachipa Upazila

Based on the analysis of the LVI result the impact of the cyclone on the livelihood of Galachipa Upazila can be categorized as 'moderate vulnerable' with an index value of 0.36. The overall vulnerability based on the socio-demographic profile is 0.23 indicating moderate adaptive capacity of Galachipa Upazila during cyclonic disasters. The percentage of dependent people is 32.36 which represent moderate vulnerability. Most households in Galachipa are male-headed; even female-headed means males are outside the home. Here, only 11 percent of households were female-headed and the average age of female household heads is 41.91 which is fairly good. Education makes people more aware and able to adjust to changes in environmental conditions whereas lower literacy rates contribute to greater vulnerability. At Galachipa Upazila only 17 percent of the household heads did not go to school. This indicates that the educational background of the households is comparatively well.

The livelihood strategy components value is 0.37 shows the study area as moderately adaptive capacity due to cyclonic disasters. 29.46 percent of households had family members working outside the community which contributes to overall vulnerability. The index value of types of houses is 0.60 indicates less vulnerability in the study area. Here, 25 percent of households are solely dependent on agriculture, and 14 percent of households are solely dependent on livestock and fishing for their livelihood. This group of people is highly vulnerable to the cyclone that Galachipa experiences.

The overall social vulnerability index is 0.40 is measured by the extent of cooperation between relatives and peoples' faith in the local government presents less vulnerability in the study area. The average receive and give ratio is 1.19. This High amount of borrowing indicates financial stress, less capacity to adapt but strong bonding between the neighbors and relatives. People have not gone to the local government for help around 66 percent show people's lack of faith in the government representatives. The percentage of households without a button phone/android phone is 7 and without television 36 indicates at the time of hazard people of the study area are aware of hazard occurrence and preparation results in less vulnerability.

The overall health vulnerability of Galachipa Upazila is 0.32 representing moderate sensitivity of the study area. The average travel time to the health facility to Upazila Hospital or MBBS doctor is around 1 hour 28 minutes which seems to take a long time and represents the high vulnerability of the area. 27 percent of households considered they had a chronic patient in their family as well as 23 percent said that a family member had to miss or work due to sickness indicating moderate sensitivity of the study area.

The whole food vulnerability index for the study area is 0.357 presenting a moderate sensitivity of the study area. More than 63 percent of households depend solely on agriculture and livestock indicating high sensitivity. More than 43 percent of households do not or cannot save crops for emergencies which increases the social vulnerability. The households struggle for less than 1 month for food in this area.

Water is available in the study area. The overall water vulnerability index is 0.44 which presents higher sensitivity in the study area. The shorter the time to collect water presents the less sensitivity. In the study area, the average time to the nearest water sources is only 3.17 minutes. 84 Percent of households obtain water from ponds, rainwater, and tube wells implying higher sensitivity. 37 Percentage households reported that they do not have a consistent water supply. Many of the households complained of water not coming through the tube wells. Especially the respondents suffer from water during drought season.

The last component is the natural disaster and climate variability component. The LVI index value is 0.36 presents the study area as moderate exposure to cyclones. The index value of Cyclone events in the past 13 years from 2007 to 2020 is 0.50 indicates cyclones visited this area almost every year (once or twice a year) and cause devastating destruction. 9 percent of the households did not receive a warning about the disasters represents less vulnerability. The average distance to reach the cyclone shelter is 1.1 kilometers and only 13 percent of people go to shelters. Again, the total cyclone center at Galachipa Upazila is only 78 for 86819 inhabitants (Galachipa Upazila DM Plan, 2014) and the average capacity of cyclone shelter is only 428.85 which is very poor to combat cyclones. Almost 7 percent of household faces disaster-related death or injury. The deviation of monthly average precipitation and temperature has shown a dramatic increase in recent years, which indicates high climate variability.

Table 2: Calculating Livelihood Vulnerability Index (LVI) for Galachipa Upazila, Patuakhali Districts

Major Component	Sub-components	Sub-component value	Maximum value	Minimum value	Index value	Galachipa Upazila
Socio-demographic profile	Percentage of Dependent people(0-14 <64)	32.36	100	0	0.32	**0.23**
	Percentage of female headed households	11.00	100	0	0.11	
	Average age of female headed household	0.02	0.04	0.02	0.33	
	Percentage of household heads who have not attended school.	17.00	100	0	0.17	
Livelihood strategies	Percentage of households with family member working in a different community	29.46	100	0	0.29	**0.37**
	Average type of Houses	1.81	3	1	0.60	
	Percentage of households dependent solely on agriculture as a source of income	25.00	100	0	0.25	
	Percentage of households dependent solely on livestock and fishing as a source of income	12.06	100	0	0.12	
	Percentage of Households without non-agricultural livelihood income contribution	58.18	100	0	0.58	
Social networks	Average receive: give ratio	1.19	2	0.3	0.52	**0.40**
	Percentage of households that have not gone to the local govt. for help	66.00	100	0	0.66	
	Percentage of households Without button phone/android phone	7.00	100	0	0.07	
	Percentage of households without TV	36.00	100	0	0.36	
Health	Average time to health facility to Upazila Hospital (MBBS doctor)	88.20	180	10	0.46	**0.32**
	Percentage of households with family member chronically illness	27.00	100	0	0.27	

	Percentage of households with a family missing work in the last 2 weeks due to illness	23.00	100	0	0.23	
Food	Percentage of households dependent solely on household agriculture and livestock for food	63.00	100	0	0.63	**0.36**
	Average number of month household struggling for food (range 0-12)	0.14	12	0	0.01	
	Percent of households that do not save crops	43.00	100	0	0.43	
Water	Average time to water source	3.17	20	1	0.11	**0.44**
	Percentage of households that utilize a natural water source	84.00	100	0	0.84	
	Percentage of household that do not have consistent water	37.00	100	0	0.37	
Natural disasters and climate variability	Average number of Cyclone events in the past 13 years (2007-2020)	1.00	2	0	0.50	**0.36**
	Percentage of households that did not receive a warning during devastating SIDR	9.00	100	0	0.09	
	Average distance to reach Cyclone shelter (km)	1.10	2.0	0.50	0.40	
	Percentage of people do not go to cyclone shelter	87.00	100	0	0.87	
	Average capacity of Cyclone shelter (no. of people)	428.85	600	250	0.51	
	Percent of households with an injury or death as a result of cyclone SIDR	428.85	600	250	0.51	
	Mean standard deviation of monthly avg. of avg. max. daily temperature(°C) (2015–2020)	7.00	100	0	0.07	
	Mean standard deviation of monthly avg. of avg. min. daily temperature (°C)(2015– 2020)	2.37	3.01	2.17	0.24	
	Mean standard deviation of monthly average precipitation (mm)	4.93	6.44	4.67	0.17	
					Overall LVI	**0.36**

Source: Developed by authors

Based on demographics, diversity of livelihood strategies, and social network strength households of Galachipa Upazila has a higher adaptive capacity (Adaptive Capacity: 0.37). However, accounting for the current state of health as well as food and water security in the study area is highly sensitive (Sensitivity: 0.37). As discussed in relation to the Natural Disaster and Climate Variability major component, Galachipa Upazila has higher exposure (Exposure: 0.36) to climate change impacts. After combining these contributing factors scores the overall value of LVI-IPCC is -0.004 respectively. This implies that overall, in terms of climate change and variability Galachipa Upazila is moderately vulnerable.

Table 3: Calculating LVI–IPCC for Galachipa Upazila

Contributing factors	Major components	Major component values	Number of subcomponents per major component	Contributing factor values	LVI–IPCC value
Adaptive Capacity	Socio-demographic Profile	0.23	4	0.37	**-0.004**
	Livelihood Strategies	0.37	5		
	Social Network	0.40	4		
Sensitivity	Health	0.32	3	0.37	
	Food	0.36	3		
	Water	0.44	3		
Exposure	Natural Disaster and Climate Variability	0.36	9	0.36	

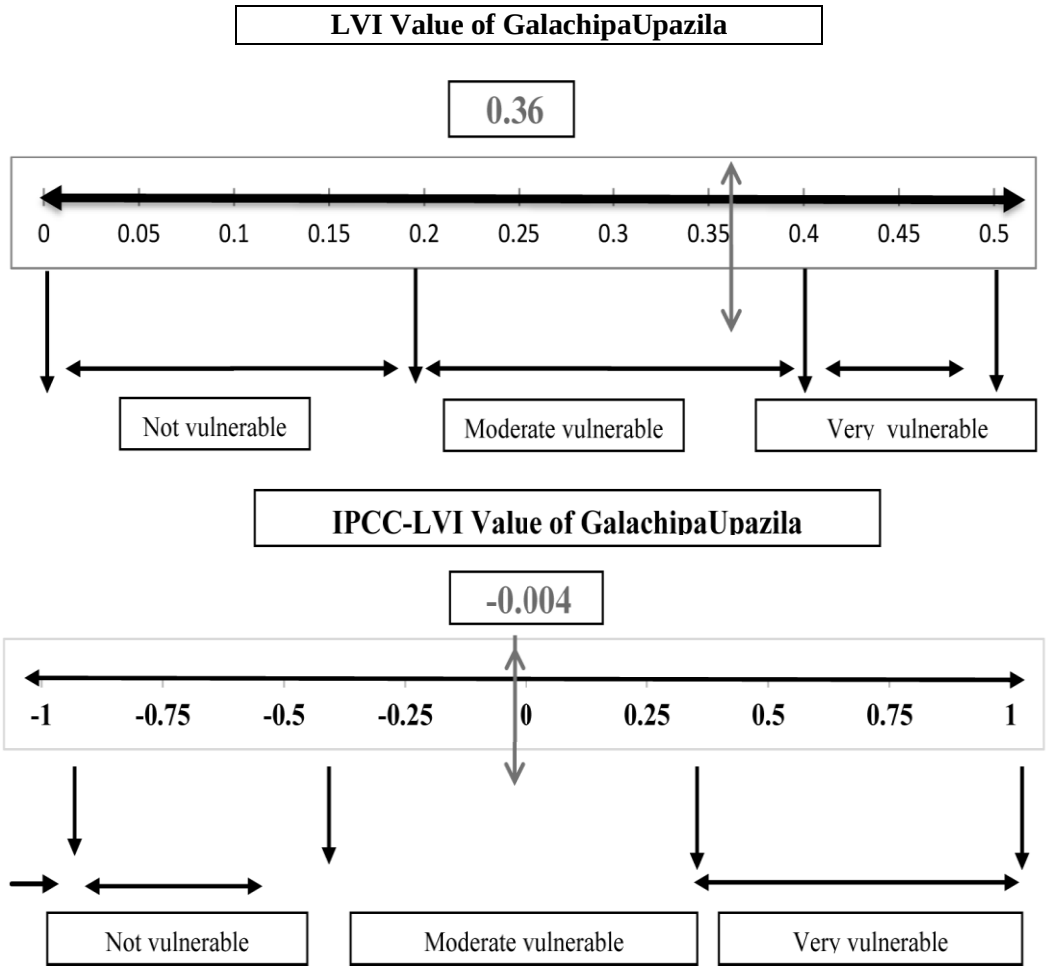
Source: Developed by authors

6.0 Discussion

From the above and from discussions it is evident that the LVI value of Galachipa Upazila is 0.36 representing moderately vulnerable. The overall value of LVI-IPCC is -0.004 also suggests that Galachipa Upazila is moderately vulnerable. So, The IPCC-LVI result agrees with the LVI result. Among the major components, Natural disasters and Climate Variability seem to have contributed highly to the overall vulnerability whereas water, education and health were the lowest contributing factors as well as community adaptation capacity is quite good for

adapting quickly to any changing conditions. The study finds that the local people give more importance to livelihood than life and so many people have died during SIDR because they did not go to shelter but went fishing in the river or went to catch fish. So, it can be said that all the aim and objectives of the studies have significantly been achieved in the studies and thus has become clear that the cyclones in the coastal areas especially the SIDR has exerted some acute and clear impacts on the life and livelihood of the inhabitants of the coastal people of Bangladesh.

LVI and IPCC-LVI result of GalachipaUpazila



(Source: prepared from field data, 2020)

7.0 Conclusion and Recommendations

The cyclone history of Bangladesh shows that the Galachipa Upazila is one of the most cyclone-prone areas with few exceptions due to topographic conditions. All major historic cyclones affected the area partly and sometimes catastrophically. This paper reveals the impacts of cyclonic storms on the people of Southern Bangladesh. Particularly assesses the effects of Cyclone on the livelihood of coastal inhabitants of Galachipa Upazila especially focuses on SIDR. Most of the People in the study area said that Cyclone is a common phenomenon to them. They can't avoid cyclonic hazards. So they have to exercise coping with cyclones. This study used LVI and LVI-IPCC as alternative methods for assessing the vulnerability of the community and finds that Galachipa Upazila is moderately vulnerable to climate and environmental change. Most of the cyclone-affected and non-affected people mentioned at present the coping capacity of cyclones has been increasing and social media and NGOs also play a significant role in training the people about the frequency of cyclones and making them aware and prepare. Local Govt. and the people of the study area have the intention how effectively cyclone mitigation procedures can be adopted and can reduce the risk of cyclonic disaster. But felt upset as there need a bold decision from the Central Government level.

In order to make the communities resilient to climate change-induced natural hazards, GOs and NGOs as well as local people should be more constructive, responsive, and technologically advanced in their work. This can be done by introducing multifarious climate-independent job opportunities. Constructions of new cyclone shelters with even spatial distribution with improved accessibility are a dire need, as most of the study unions do not have enough cyclone shelters to accommodate local people. Gender issues must be considered in designing cyclone shelters. Separate space for livestock is also needed. Controlling salinity intrusion for shrimp culture and encouraging the fish farmers to freshwater shrimp culture. Providing loans at a low rate of interest to recover from post-disaster situations as well as giving importance to repairing, maintaining, and constructing roads and embankments for a better transportation network. Emergency relief and cyclone preparedness program needs to be strengthened to fight increased climatic events. The establishment of health care facilities in the study areas is a dire necessity for preventing climate-induced diseases. Various research programs to incorporate local knowledge for climate change adaptation are required in the study area. Again, Urgent response actions are still required for vulnerable groups, support for housing rehabilitation and sanitation, and emergency healthcare interventions.

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