



**MAURITIUS RESEARCH COUNCIL**

**EVALUATION OF THE VULNERABILITY OF  
COASTAL COMMUNITIES TO CLIMATE  
CHANGE IN THE ISLAND ECONOMIES - A  
CASE STUDY OF THE REPUBLIC OF  
MAURITIUS**

**Final Report**

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**EVALUATION OF THE VULNERABILITY OF COASTAL  
COMMUNITIES TO CLIMATE CHANGE IN THE ISLAND  
ECONOMIES – A CASE STUDY OF THE REPUBLIC OF MAURITIUS**

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# **EVALUATION OF THE VULNERABILITY OF COASTAL COMMUNITIES TO CLIMATE CHANGE IN THE ISLAND ECONOMIES – A CASE STUDY OF THE REPUBLIC OF MAURITIUS**

## **1. EXECUTIVE SUMMARY**

In the context of this research, climate change relates to the potential extreme weather events that may occur in and around Mauritius that will have severe adverse effects, including injuries, loss of lives, on the economic and social lifestyles of certain coastal communities of the island. Extreme weather events may be referred to as intense tropical cyclones, droughts, flooding and wave surges and sea level-rise amongst others.

The main aim of the present research is thus to assess the vulnerability of coastal communities by tracking the potential immediate effects of these extreme weather events on such people while at the same time tracking the latter's readiness to face them. 422 interviews were in fact conducted in four villages, namely, Pointe aux Piments, Rivière des Gallets, Case Noyale and Quatre Soeurs. These villages were chosen due to their immediate exposure to certain natural calamities and as revealed by GIS maps and current observations. Interviews were also backed by discussions through Focus Groups in these villages prior to the survey, in addition to local authorities as Key Informants

The findings of this research may constitute the basis for a preparedness plan to address the dangers that lurk around these coastal villages and hence help to greatly reduce the risks of injured people, loss of lives, social and economic losses of current and future generations. Moreover, the report may serve its purpose in helping communities to better adapt to more extreme weather conditions that may occur ultimately and to establish mitigation plans altogether.

Using Sustainable Livelihoods approach, this research also found that the most vulnerable ones will not be able to develop resilience and will find it tough to reduce their degree of vulnerability in the long run. Indeed, this approach is concerned with the evaluation of five forms of assets that will indicate the robustness of households to sustain their livelihoods and to face extreme weather situations. These assets are human capital, social capital, natural

capital, financial capital and physical capital. We also extend this methodology to capture the response of authorities through institutional capital. Such approach will help tracking the most vulnerable ones given their status based on the different forms of capital/assets that they own. Exposure to extreme weather becomes thus a generational concern with the absence of carefully crafted policies and action plan by concerned authorities.

Findings of this research reveal, amongst others, that the poor communities are the ones at risk. Three levels of vulnerability were ascertained and analysed, namely, Sustainable Livelihoods Vulnerability (SLV), Loss of Life Vulnerability (LLV) and Loss of Output and Income Vulnerability (LOIV). SLV is also a measurement of the vulnerability of the households over the long term and helps to indicate the degree of resilience that could be built up by them. In this category, it was found that 34 individuals scored the maximum points of 27 used in the computation of this form of vulnerability. Out of the 34, 13 were female respondents. With respect to LLV, it was found that there are 17 people who are at immediate risks of being severely injured or losing their lives as they are highly exposed to the danger of storm surges, flooding and wave surges. Out of this figure, 9 were found to be women. Lastly, LOIV relates to small scale planting and farming communities whereby it was found that 14 respondents are vulnerable and of which 6 are women. These are people whose income depends to large extent on nature and weather conditions.

The income of those people who are vulnerable in all the three categories are found to be households deriving a monthly income of Rs 5,000 or less (Rs 7320 is the official income threshold below which an income earner is considered to be poor) , they live very close to the shore, they do not own their house and land, the house is made up of iron sheets and wood while their income is dependent on the caprices of nature.

People's perceptions reveal that they mostly believe that climate change is actually reflected in hotter summers, more recurrent droughts, higher frequency of tropical cyclones and as well as sea-level rise. Among the effects, quite a large number of respondents are particularly concerned with the hike in prices that occurs after severe weather conditions for vegetables.

The surveyed communities are directly concerned with water shortages, flooding, sea-level rise, storms surges while these are compounded by land slides, land erosion, droughts, increasing pests and insects including vector-borne diseases. Small planters and farmers have

revealed to what extent their output is adversely affected by bad weather conditions, resulting in loss of income. Coral bleaching, increased sedimentation in the lagoons and degradation of the coastal and marine environment do also badly contribute to the reduction in fish catch.

Almost 50% of those who were interviewed, and who do suffer from an illness, have indicated that their health status is related to climate change. They usually do not have the means to bear their treatment expenses. Around 45.1% people have also indicated that their mobility is affected during extreme weather due to damaged roads, fallen electric poles, flooding and lack of transport. Despite their high involvement in local associations that aim at improving the welfare of all members and citizens, there is little which is currently being done to enlighten the inhabitants on climate change and its implications.

There are still 20.1% of people interviewed whose houses are either made of wood or iron-sheet or both. These people have also been found not to have water storage facilities. Quite a few (about less than 2%) of the interviewed households still do not have access to water and electricity.

About a quarter of those interviewed related that they do use their land and property to do farming or grow vegetables for sale. More than 80% of these people have indicated that their businesses are highly vulnerable to extreme weather conditions. They expect that losses encountered by them in the past would definitely increase. The problems related to businesses are water shortages, lack of water storage facilities, poor infrastructure, low crop resistance, low soil fertility amongst others. The support for financial assistance is reported to be remote while they do not have a concrete business plans to address climate change impacts in the long run.

Almost 50% people interviewed would wish government to improve its services provided thereby encompassing more climate-change facilities, financial support and long term scheme to reduce their vulnerability. Findings from this survey also revealed that significant institutional support is needed to provide assistance, in kind and in cash, to help the vulnerable people as well as the small farmers and planters prior to, during and after extreme weather conditions.

Some major policy recommendations are:

- Development of a preparedness plan of action to address climate change whereby local government, in particular, District Councils, could be financially empowered in the face of expected extreme weather events in the near and distant future
- The Maurice Ile Durable project might be a good platform to design measures that would improve the resilience of coastal communities to climate change in a holistic manner
- The setting up of a Climate Change Observatory. This observatory would make an inventory of the socio-economic and environmental costs/damages arising from climate change, that is, due to extreme weather events observed at Mauritius. It would have to publish an annual report that would provide guidance, accountability and responsibility of authorities to better address the multi-faceted consequences of climate change. This observatory would also recommend the funding of projects and plans in line with adaptation and mitigation strategies
- Among other strategies highlighted in this research is relocation plan for communities who are at immediate risks such as squatters and people who stay close to the shore and whose houses are highly exposed
- Unprotected coastal areas should be given special attention to arrest beach erosion, rebuild the marine ecosystem and prevent sedimentation of the lagoons
- Disaster-prone lands must be identified and mapped out as a priority to rebuild public infrastructure. Private owners could be advised on how to address any defect in their infrastructure to reduce the risk and degree of flooding
- Water shortages could be dealt with in dry regions through harvesting of rain water by people and commercial enterprises to improve their storage and be less dependent on the Central Water Authority (CWA)
- The planting and farming communities would require necessary training and funding schemes as well as guidance on how to mitigate risks especially through new techniques to develop resilience, to revisit their irrigation and water storage infrastructure, to combat weather-related diseases and improve agricultural productivity

- A Climate Change Insurance scheme could be set up for small planters and farmers on a tier basis, with the government providing a first tier to compensate losses in output and income following natural hazards
- Greater medicare is required for coastal communities through mobile health facilities to assist old people whose mobility are reduced and who suffer from illnesses that are affected by extreme weather
- NGOs and local associations could be called upon to consolidate efforts at the local level to provide more knowledge about climate change, its consequences and methods that could be used for better adaptation and mitigation



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# **CHAPTER 1:**

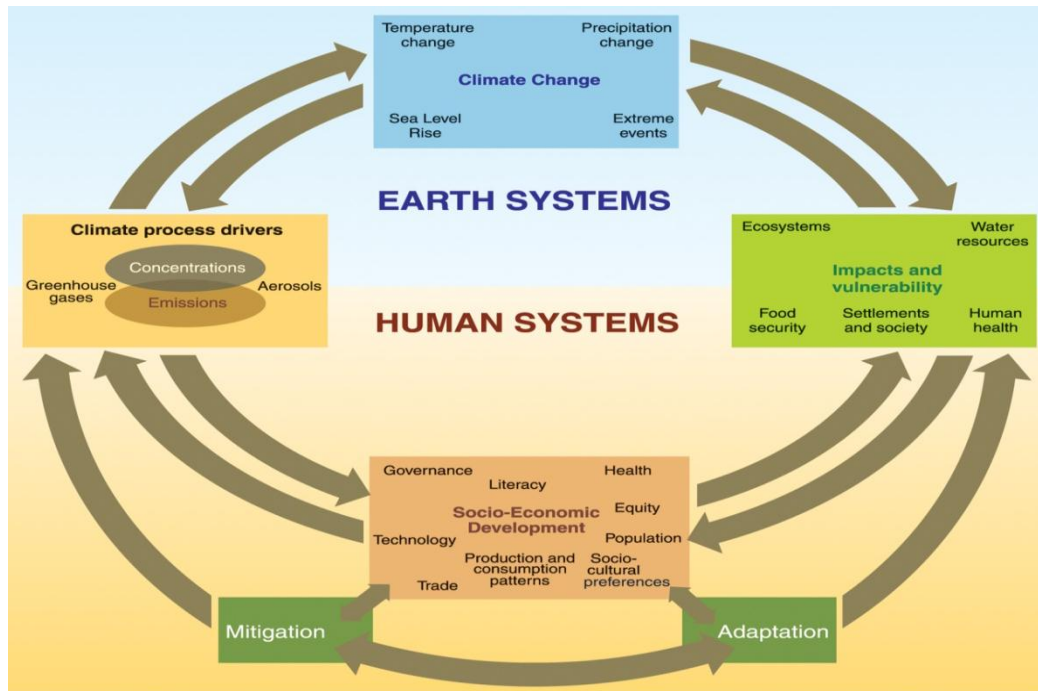
## **GENERAL CONCERNS ABOUT CLIMATE CHANGE**

### **1.0 Introductory Note**

Climate change is defined as a worldwide phenomenon that will have widespread effects on the environment, and on socio-economic and interconnected sectors, including water resources, terrestrial ecosystems, agriculture and food security, human health, biodiversity and coastal zone. Evidence shows that global temperatures have increased in the last century and presence of more carbon dioxide has enhanced the atmosphere's ability to capture heat. However, these threats are not felt equally around the world: for example, Southern countries face severe problems from desertification, while northern industrial countries deal with acid rain; and Polar Regions see large depositions of persistent organic chemical pollutants. Climate change will cause uneven effects over the entire globe for the next fifty to 100 years, with some countries benefiting and others suffering. In Europe, the heat wave in the summer of 2003 resulted in over 30,000 deaths and in India, temperatures reached 48.1 degrees Centigrade. Two years later (2005), the ferocity of Hurricane Katrina in the United States was attributed in large part to the elevated water temperatures in the Gulf of Mexico. IPCC (2007) and World Bank (2010, 2012) clearly explain the various socio-economic and environmental problems associated for different communities, especially in the developing world, and the various challenges ahead for current as well as future generations. Other recent studies, namely, Roberts (2010), Mc Leman and Smit (2006), Haines et al. (2007), McMichael et al.(2006), Cutter (1996) and Cutter et al.(2003), highlight the multi-faceted problems and complexities already being faced by communities due to climate change.

Among the most vulnerable countries, remain the small island states which, besides being coastal, are now becoming increasingly exposed to natural hazards.

Figure 1.1 below, illustrates the main causes and effects of climate change



**Fig. 1.1** Causes and Impacts of Climate Change (Source: UNFCCC)

### 1.1 Climate Change and Coastal Communities

One of the most affected victims of climate change is coastal inhabitants as they will have to confront storms of greater magnitude and frequency, rise in sea water level and ocean acidity. More precisely they are prone to the following coastal hazards:

*Sea Level Rise* - Accelerated Sea Level Rise (ASLR) is one of the most certain outcomes of global warming. The physical effects of sea level rise include inundation (submergence) of low-lying wetland and dry land areas, erosion, salt water intrusion, increased risk of flooding, and storm damages. In turn, these physical changes may cause substantial socio-economic losses of coastal structures, both natural and man-made, and dislocation of the population and change of livelihood. The same physical changes may bring about certain ecological consequences such as redistribution of wetlands, destruction of coral reefs, reduction in biological diversity and loss of wildlife, and changes in biophysical properties of the coastal zones.

*Storms* - great storms such as hurricanes or other winter storms can cause erosion of the coastline at much higher rate than normal. During such storms beaches can erode rapidly and heavy wave action can cause rapid undercutting and mass-wasting events

of cliffs along the coast, as noted above. Note that the El Niño driven storms on the west coast caused extensive coastal erosion in 1998.

*Tsunami* - a tsunami is a giant sea wave generated by earthquakes, volcanic eruptions, or landslides. Such waves can have wave heights up to 30 m, and have great potential to wipe out coastal cities.

*Landslides* - On coasts with cliffs, the main erosive force of the waves is concentrated at the base of the cliffs. As the waves undercut the cliffs, they may become unstable and mass-wasting processes like landslides or rock falls will result. Massive landslides can also generate tsunamis.

In 2007, scientists from the IPCC (IPCC (2007)) predicted that warming oceans and melting glaciers due to global warming and climate change could cause sea levels to rise 7-23 inches by the year 2100. Worldwide, densely populated coastal communities and infrastructure that supports them would be affected (such as city buildings and homes, roads, ports and wastewater treatment plants). Some would be flooded or become more vulnerable to storm damage. In flat terrain, the shoreline could move many miles inland. Major physical impacts of sea-level rise include the following:

- erosion of beaches, bay shores, and tidally influenced river deltas;
- permanent inundation or wetland colonization of low-lying uplands;
- increased flooding and erosion of marshes, wetlands and tidal flats, potentially resulting in net degradation and losses as a result of normal tidal inundation and episodic storm surges;
- increased flooding and storm damage in low-lying coastal areas as episodic storm surges and destructive waves penetrate further inland;
- Increased salinity in estuaries, marshes, coastal rivers, and coastal aquifers

These primary impacts will trigger other impacts such as damages to buildings and other coastal infrastructure, including ports, ship channels, and bridges. Where hazardous waste landfills are affected, pollutants in the landfills may migrate because

of flooding and water-table changes. As sea-level rise accelerates, these impacts may become more severe, depending on individual site characteristics and protection strategies.

At the same time the ocean is becoming more acidic, (decreased seawater pH) as it absorbs atmospheric carbon dioxide (CO<sub>2</sub>). Ocean acidification has probable widespread effects on marine life. It may slow down calcification, which will menace the survival of coral-reef ecosystems. It will reduce the growth of calcareous algae at the base of the food web and of shell-forming marine organisms (such as scallops), and it will stunt the growth of calcified skeletons in many other marine organisms, including marketable fish species. These species changes then affect local fisheries livelihoods and food supplies for coastal communities. In addition, climate change may result in changing patterns of storm damage in coastal areas, although this effect is not a result of sea-level rise. Climate change could result in more northerly storm tracks, for example, or changes in the frequency or intensity of tropical storms and hurricanes.

Some direct impacts of the above can be in terms of distortion of agricultural output, landslides, marine pollution and dislocation of fish stocks, threats to water resources, changes in coastal morphology, threats to private and public infrastructure, increasing health hazards (skin disorders, asthma, water and vector-borne diseases among others). Given, the inhabitants in coastal regions are very much dependent on the sea to earn their living directly or indirectly. Climatic disturbances affect the economic situation of inhabitants in ways as loss in agricultural/farm productivity, reduction in GDP per capita, rising Public Expenditure to address the above, higher tax liabilities, forced displacement of coastal communities, redeployment of certain category of workers such as fishers and relocation of particular hotels. Within the coastal areas communities, most vulnerable are those with poor climate-resistant dwellings and a high dependence upon fishing livelihood and eco-tourism.

## CHAPTER 2:

### THE VULNERABILITY OF COASTAL COMMUNITIES IN SIDS

#### 2.0 Coastal Threats and Socio-Economic Damages

The climate of Small Island Developing States (SIDS) is influenced by large ocean atmosphere interactions such as trade winds, El Niño and the monsoons. SIDS are characterised by the concentration of large settlements with associated economic and social activities at or near the coast. In SIDS, arable land, water resources and biodiversity are already under pressure from sea level rise. Increases in population and the unsustainable use of available natural resources add further problems. Tropical cyclones cause storm surges, coral bleaching, inundation of land, and coastal and soil erosion with resulting high-cost damages to socio-economic and cultural infrastructure. For example, in the Pacific islands region, cyclones accounted for 76% of the reported disasters between 1950 and 2004, with the average costs relating to damage caused per cyclone standing at USD 75.7 million in 2004 value (World Development Report 2010). In the Caribbean region, the 2004 hurricane season alone caused damages estimated at USD 2.2 billion in four countries: the Bahamas, Grenada, Jamaica and the Dominican Republic.

The development and growth of these countries are also hindered by high communication, unequal international transport volumes energy and transportation costs, disproportionately expensive public administration and infrastructure due to their small size, and little opportunities to benefit from economies of scale.

Vulnerabilities include low availability of resources, a small but rapidly growing population, remoteness, susceptibility to natural disasters, excessive dependence on international trade, and vulnerability to global developments. Water supply in SIDS is likely to be exacerbated by future climate change. Freshwater lenses are predicted to reduce in size due to increased demand and reduced rainfall. Freshwater supplies are also threatened by saltwater intrusion due to storm surge and sea level rise.

The projected impacts of climate change on agriculture include extended periods of drought, loss of soil fertility and shortening of the growing season which will lead to major economic losses and seriously affect food security. On many islands, prime



agricultural land is located on the coastal plains which are already threatened by sea-level rise. The relative magnitude of economic losses due to climate change is likely to differ across islands. For instance, in the absence of adaptive measures on a high island such as Viti Levu in Fiji, the cost of damages could be in the range of USD 23 – 52 million per year (2% – 3% of GDP) by 2050 whereas in a low island such as Tarawa, Kiribati, the annual average cost of damages would be in the order of USD 8 – 16 million (17% –18% of GDP) by even more for other countries by 2050 (see for instance World Bank 2012).

Increasing temperatures and decreasing water availability due to climate change may also increase the burden of diarrhea and other infectious diseases in some Small Island States. Increases in tropical cyclones, storm surges, flooding, and drought are likely to have both short and long-term effects on human health, including drowning, injuries, increased disease transmission, decreases in agricultural productivity and subsequent malnutrition.

Coastlines will almost certainly suffer from accelerated coastal erosion as well as inundation of settlements and arable land with associated social and economic consequences. For example, in Grenada, a 50 cm rise in sea level could lead to serious inundation with 60% of beaches in some areas being lost. A one-metre rise in sea level is expected to cost Jamaica USD 462 million, 19% of its GDP ; while for the Maldives a one-metre rise in sea level would mean the complete disappearance of the nation (see UN( 2001)).

Sea level rise, increasing sea surface temperatures and acidification of the oceans will entail a loss of mangrove forests and coral reefs and reduced fish stocks throughout this region. For example, studies have projected that 3% of Cuba's mangrove forests may be lost with a one meter rise in sea level. For the same rise in sea level a complete collapse of the Port mangrove wetland in Jamaica is predicted, since this system has shown little capacity to migrate over the last 300 years (Nurse et al. (2001)).

Climate change is also likely to have a negative effect on tourism in SIDS, seriously affecting the economy of many Small Islands. The increasing frequency and severity

of extreme weather, sea-level rise and accelerated beach erosion, degradation of coral reefs (including bleaching), and the loss of cultural heritage on the coasts through inundation and flooding are likely to reduce the attractiveness of Small Island States to tourists. In Barbados, for example, 70% of the hotels are located within 250 m of the high watermark. This suggests that many hotels are almost exclusively within the 1 in 500 and 1 in 100 inundation zones, placing them at risk of major structural damage.

Ibidun and Adelekan (2009) studied 486 households along the coast of Lagos to assess the impacts and vulnerabilities of those households to the growing risks of floods arising from climate change. Over 50 per cent of the respondents' houses were located less than 500 metres from the coastline. The results revealed that the problem of flooding was aggravated by the inadequacy of the drainage network within the regions, which was neither efficient nor complete. One proposed coping strategy was sand filling of rooms on an annual basis which would cost between 6000 and 15000 Nigerian Dollars per wet season and as such not an accessible option for those unemployed or with low income levels. Furthermore, because majority of the population in these communities were artisans and traders, the constraint of economic activities due to floods made them more vulnerable as they did not have alternative livelihoods.

A socio-economic study of Rivière Banane in Rodrigues, by Marshall et al. (2010), exposed that high dependence on farming and fishing in the region, made the communities more vulnerable to climate change. Local inhabitants claimed that farming yields had already been affected as changes in rainfall patterns and air temperature had been observed. The sea was also perceived as increasingly rougher, cooler and as having risen.

## **2.1 Mauritius**

Indian Ocean region is particularly susceptible because the Island climates' in this region are dominated to a great extent by the Asian Monsoon system, made up of the southwest or summer monsoon and the northeast or winter monsoon. These climatic characteristics and their particular socio-economic situations as stated above make SIDS among the most exposed countries in the world to climate change. Existence of

these problems and combined with the fact that SIDS generate enormously low levels of greenhouse gases (GHG), implies that they will undergo disproportionately from the destructive impacts of climate change. One such vulnerable island located in the Indian Ocean is Mauritius, with an area of 720 sq miles and an estimated population of around 1.2 million.

## **2.2 Threats to Mauritius due to Climate Change**

Due to climate change the island has been experiencing several threats such as decrease in number of rainy days but increase in its intensity, higher precipitation rate leading to adverse crop yields and adverse impacts on animal reproduction due to heat stress. Yet of all the threats facing island, the rise in sea level (Sea Level Rise-SLR) could be the most catastrophic. As stated by Boko et al. (2007), losses to Small Islands arising from SLR may exceed 14% of GDP. Moreover, according to the MMS (2008) the islands within the Republic of Mauritius (Mauritius, Rodrigues and Agalega) will experience a sea-level rise of 18 – 59cm by 2100. In addition it was noted that the summer 2008-2009 experienced abnormally high sea surface temperatures in the South West Indian Ocean (SWIO).

The SWIO Islands countries are realizing the tough realities of the effect of climate variability and climate change now occurring at a faster pace than ever before. Mauritius, similar to most SIDS, has every reason to worry about what may be in store for it. Its physical size and geographical isolation, its proneness to natural disasters and climate extremes, its reliance on imports and its low adaptive capacity, will increase its vulnerability and reduce its resilience to climate variability and change. Mauritius has recognised that much effort is needed to reduce the impacts of climate change on the natural and human environment of the country. In addition to the current cyclone warning system, the meteorological services do issue torrential rain warning as well as high waves warning. These are issued at more frequent intervals as well.

It is well known that climate change has a multi-faceted influence, but as far as the coasts are concerned, climate change impacts range from rising sea and air temperatures, mass coral bleaching, rising sea levels causing the inundation of crops and the contamination of water supplies with salt water, acidifying oceans,

intensifying storms, to changing rainfall patterns and ocean currents. There exists an increasing number of marine sites experiencing ecosystem level damage (including biodiversity) due to anthropogenic activities and climate change driven events. Research by some conservation organizations (e.g. Conservation International) suggests that species are heading towards extinction at a rate of about one every 20 minutes. Some of the marine ecosystems such as the coral reefs have been predicted to have “extinction dates” as early as 2010 (Sheppard (2003)). The consequences of such a loss entail lower fish abundance and numbers, lack of clean water, fewer opportunities for livelihoods, decreased quality of health, education and life and lack of marine resources like food and pharmaceuticals. These, in turn, imply decline in income for primary stakeholders including local communities belonging to mostly the low-income earning population. The latter are more vulnerable since poverty implies limited or no ownership of assets, and limited or no access to credit, information and opportunities and insurance against risks and hence any change represents a risk. Alongside, poor people/households tend to occupy the least productive and most disaster-prone lands or unprotected coastal areas, which in turn, make their coping strategies to climate change unsustainable and exacerbates their vulnerability (see for instance papers by Desai et al. (2007), Hoblay et al.(2006) and Mander et al. (2007))

As far as Mauritius and its dependency Rodrigues are concerned, they fall right on the trajectories of intense tropical cyclones. Generally speaking, we expect on average 11 storms to form in the South West of the Indian Ocean, while in some exceptional years this figure could reach 15 (1993/94 season) and 3 (2010/2011). Some of these may reach the level of super storms (gusts exceeding 320 km/hr with 500 inches of rain poured during their passage close to or over the islands). While it is not very sure whether the number of storms will increase in frequency and intensity, the coastal communities should be prepared for the worst scenarios. Be it a storm or flood event, the damages could be enormous along with loss of lives. It is known that the fatalities of storms and hurricanes could be among the highest ones (see UNDP (2008)). All in all, the marine ecosystem might be subjected to unparallel stress.

Though analysis of data from Mauritius Meteorological Services does not show any increase in the number of storms in the South West Indian Ocean basin (SWIO) in recent years, see Table 2.1 below, the island is exposed to very intense tropical

cyclones that generate gusts of wind exceeding 250km/h accompanied by torrential rains. Such tropical cyclones are also responsible for wave surges that threaten the lives of people, cause severe damages to public and private infrastructure, agriculture and farming, and lead to beach erosion, amongst others.

**Table 2. 1: Worst Tropical Cyclones Affecting Mauritius, 1960- 2012**

<b>Name and Year</b>	<b>Maximum Wind Speed Recorded in Km/h</b>	<b>Maximum Amount of Rain Recorded in mm</b>
<b>Alix (Jan 1960)</b>	200	<b>645</b>
<b>Carol (Feb 1960)</b>	256	<b>508</b>
<b>Jenny (Feb 1962)</b>	235	<b>185</b>
<b>Danielle (Jan 1964)</b>	216	<b>795</b>
<b>Gervaise (Feb 1975)</b>	280	<b>533</b>
<b>Claudette (Dec 1979)</b>	221	<b>300</b>
<b>Hollanda (Feb 1994)</b>	216	<b>494</b>
<b>Dina (Jan 2002)</b>	<b>228</b>	<b>711</b>

Source: Padya (1989) and Technical Reports, Mauritius Meteorological Services

The above table very clearly indicates the potential intensity of tropical cyclones that can devastate human habitats, vegetation and bring a lot of economic losses to the country. From some past records (Padya (1989)), cyclones Alix and Carol reduced the sugar production by 50% in 1960 and 40 people were reported dead during the passage of cyclone Carol. With an improvement of the warning system (established in 1960) and media development, the number of deaths has been reduced significantly thereafter, for instance, 5 deaths were reported during cyclone Gervaise of 1975 and 2 during cyclone Hollanda (1994).

However, it cannot be discarded that with more frequent and intense storms, there would be necessarily no death or real dangers. The effects of climate change on temperature, precipitation rate and sea level rise in turn would result in inundation and displacement of wetlands, coastal flooding and loss of agricultural land around the coast and salinization of irrigation water. Moreover, there would be increased risk of land being wiped out, latent risk of higher losses to be borne by insurance companies, danger to marine life as fertilizers filter down the rivers and the sea and change in spatial distribution of fish stock and negative effects on the aquaculture system.

The impacts of climate variability and extreme weather events are becoming a concern to the Republic of Mauritius including Rodrigues, St Brandon and Agalega. The climate of the SWIO Small Island States is influenced by large ocean-atmosphere interactions such as trade winds. They are often affected by tropical cyclones and other extreme weather. Some of them like the Saint Brandon or the Cargados Carajos Shoals and Agalega Islands are threatened by sea-level rise as well. Over the past five years, for example, between 2007 and 2012, Mauritius has experienced two episodes of excessive rainfall causing flooding, loss of lives and economic damages and one extreme drought period. The latter too was very damaging to the economy. It has thus become very difficult to predict the type of extreme episodes that may occur thus necessitating a preparedness plan in order to mitigate the effects of any weather hazard.

Though the GHG emission of Mauritius is insignificant, warming of our climate and its effects on our natural and ecological system are unavoidable and already palpable. Analyses of temperature recorded at Mauritius and its outer islands show a definite warming trend. Average temperature at all stations is rising at the rate of 0.15 °C per decade and has risen by 0.74 – 1.2 °C when compared to the 1961-90 long term mean. At some urban stations the temperature has risen by even greater amounts.

IPCC 2007 report concludes that average ocean temperature from surface to a depth of 700 meters has warmed up, though land surface temperature has increased more than ocean water temperature. Warming of the atmosphere has also impacted the hydrologic cycle<sup>1</sup> over the southwest Indian Ocean. Long-term time series of rainfall amount over the past century (1905 to 2007) show a decreasing trend in annual rainfall over Mauritius. Annual rainfall over the outer islands indicate significant variation from year to year but long-term analysis do show decreasing rainfall trend, though lesser than the main island Mauritius (Meteorological Services (2012)). Impacts on the primary parameters, temperature and rainfall will result in secondary but no less important consequences:

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<sup>1</sup> From a raging stream during spring snowmelt, to a gentle summer rain, to the slow movement of water through the ground, water is in constant motion. The movement and endless recycling of water between the atmospheres, the land surface and underground is called the hydrologic cycle. This movement, driven by the energy of the sun and the force of gravity, supplies the water needed to support life. Understanding the hydrologic cycle is basic to understanding all water and is a key to the proper management of water resources.

- a lengthening of the intermediate dry season, the transition period between winter and summer, has been observed; there has been a shift in the start of the summer rains which is highly significant as it translates into much pressure on the water sector to meet increasing demands of the agricultural, tourism, industrial and domestic sectors;
- the number of consecutive dry days is increasing while the number of rainy days is decreasing; even though the number of rainy days is decreasing, heavy rainfall events leading to numerous flash floods and temporary interruption of certain socio-economic activities during the summer months of February and March have increased;
- the frequency of extreme weather events, heavy rains and storms of tropical cyclone strength or higher, has increased significantly over the last two decades; the capacity of ecosystems to adapt will be exceeded, with negative consequences such as an increased risk of extinction of species; fisheries and aquaculture will be adversely affected as our marine ecosystems fall prey to rising temperatures;
- coastal areas will be exposed to increasing risks of coastal erosion, due to sea level rise whereby an increase in 5 cm in the sea level may translate into the effect of an increase of one meter during cyclones or tidal surges and coastal ecosystems such as coral reefs, wetlands, and mangroves will be negatively affected; extent of flooding of coastal zones that will be exacerbated by cyclones and tidal surges will increase; traditional and present crop varieties will suffer, impacting severely on food security;
- Human health and well-being will be negatively affected by rising temperatures, bearing in mind that human endurance to heat has limits; and increased incidence of diseases is very likely together with more extensive proliferation of infectious diseases.

It must be noted that local monitoring activities show that coral cover around Mauritius Island has declined gradually by about 20% – 70% within a decade (from 1999 to 2009), implying a limited level of natural recovery (see for example Sheppard (2003)). Though coral reefs in Mauritius represent less than 0.1% of the global coral

reef area, an estimated USD148 million per year contribution is made in terms of ecosystem services. A 20% - 70% decline in potential economic benefits from our reefs can be predicted due to the current level of decline of coral cover. Livelihood of local communities directly dependent on coral reefs resources will be severely impacted and can perpetuate a cycle of poverty. The loss of biodiversity can result in serious consequences, be they in the immediate or far future.

Some of the direct socio-economic impacts of the extreme atmospheric disturbances associated with global warming that are relevant for island economies and observed at Mauritius is as follows:

- Distortion of agricultural output
- Reduction in livestock
- Land slides
- Marine pollution and dislocation of fish stocks
- Threats to water resources
- Changes in coastal morphology
- Threats to private and public infrastructure
- Increasing health hazards (skin disorders, asthma, water and vector-borne diseases etc)
- Water shortages

Till date, no studies have been carried out to assess the degree of vulnerability and adaptation to climate change in the light of increased climate variability and major irreversible impacts. At the same time gender-sensitive methodologies to capture the impact of climate change are almost absent in the context of SIDs and coastal communities. Alongside, focusing only on the impacts of climate change as a starting point of analysis has serious limitations. Firstly, it is uncertain where and when the climate impacts will occur. Secondly, focusing on impacts will be treating mainly the symptoms and not the causes. Therefore, besides climate change, impacts need to be addressed with their other underlying causes. To overcome this weakness there is further call to also focus on vulnerability. This research caters for these gaps in the



literature and also attempts to assist the government to establish a preparedness action plan addressing economic and social consequences of forthcoming weather extremes. Furthermore it must be noted that vulnerability in itself does not cater for adaptive capacity and as such this research will take a step further to analyse and evaluate how could resilience be developed what form of governance must be set up to ensure a smooth socio-ecological system in place.

### **2.3 Objectives**

To assess the vulnerability of coastal communities in the context of Mauritius, and to address the various gaps in the existing literature, we set the following objectives.

- Combining and compiling existing records from scientific research and NGOs documentations in order to take stock of the current status of potential threats already identified by various stakeholders and the current mitigation plans (if any) that have been or currently being implemented to address climate change issues at the national level. This will also shed light on the degree of commitment of institutions (local and external) towards a holistic approach related to climate change and global warming especially bearing in mind the human aspects often overlooked in climate change-related studies.
- Tracking the potential threats to fishing, farming and agricultural communities as trading/commercial to extreme climatological/atmospheric disturbances. Climate change is usually associated with huge potential losses to communities that are climate-dependent such as farmers, agriculturists and fishers, amongst others. Their outputs and incomes are dependent on the evolution of the weather and prevailing conditions. Hence, it is paramount to analyse threats to the economy, employment and livelihoods with respect to these communities in particular. Threats to these people may as well entangle linkage effects threatening other communities as well
- Assessing the coastal communities' loss in terms of capabilities and functioning. A major aspect of this research is to analyse the sustainable livelihoods of the coastal communities. This is particularly important given the threats to business communities, economically-disadvantaged populations, self-dependent women, senior citizens and dependent people. Lack of

awareness and perception of the dangers associated with climate change may entangle huge losses, human, economic, social, institutional and environmental. Our study will bring together different forms of capital to take stock of the threats to all concerned parties using thus a holistic approach

- Identifying the most vulnerable people and communities who are the most immediate ones to be affected by extreme weather events in particular, floods, tropical cyclones and droughts. Moreover, the proposed methodology will help as well to identify the extent to which communities may develop resilience over time or will become less vulnerable to climate change
- Scoping the role of public and private institutions in addressing climate change issues. As far as the Government Organisations (GOs) are concerned, the effective roles played by both local and central governments have to be demarcated clearly. Climate change will eventually involve greater commitments, financial and administrative, towards communities at risks and such that these have to be well analysed along with gaps that currently exist to formulate robust policies altogether. On the other hand, private stakeholders' roles have to be thrashed out, in particular, through the Corporate Social Responsibility (CSR) for private firms, such as hotels, restaurants and tour operators amongst others. The roles of NGOs (such as community-based associations, nature-based associations and charitable institutions) have to be understood. All these will be taken into account to know the degree of commitment of institutions that are directly and indirectly concerned with the threats to communities and the local economy
- Determining the options for change in policies and business practices that would help to better adapt to climate change, particularly for capacity building and awareness campaigns. All in all, the project provides the necessary recommendations for a preparedness plan to help in better adaptation, mitigation and relevant plans that are needed in order to prevent deaths, food insecurity, and loss of output, income and employment and get the entire nation more conscious about the implications of climate change and extreme weather events
- Lastly this research does also benefit the academic community in providing an extension in the literature on climate change in SIDS, using Mauritius as an

upper-middle income country. The proposed methodology of Sustainable Livelihoods is extended to include institutional capital to provide more insights into and scope for policy support and intervention. Lack of institutional reforms may leave communities vulnerable across generations. Hence, the case of Mauritius undoubtedly enriches the existing body of literature.

## **CHAPTER 3:**

### **METHODOLOGICAL ISSUES**

#### **3.0 Introductory Note**

This research uses primarily the Sustainable Livelihoods Method to ascertain and analyse the vulnerability of coastal communities. This method is elaborated in the next section. However, to apply this methodology, there was need to gather primary data through a carefully worked out questionnaire to be administered to the four villages already mentioned. In addition, we also use secondary data to compare certain results and to benchmark the primary data to be at par with existing information as gathered by the Central Statistics Office (CSO).

#### **3.1 Sustainable Livelihoods Method**

This research uses the Sustainable Livelihoods assets approach (see DFID (2000), Allison and Horemans (2006) and Roberts (2010)) to determine the extent of vulnerability of coastal communities. This is going to be based through a well crafted questionnaire. The advantages of this methodology are that it provides, firstly, the scope for tracking those people who are at an immediate risk facing extreme weather situations, hence the most vulnerable ones, and secondly, it helps to ascertain the resilience of the studied households. In short, both the short run and long run vulnerability can be ascertained. Besides, this framework is very practical and in line with surveys that capture the demographic characteristics of respondents but integrating them in a much more comprehensive manner than would a simple survey. The assets used in the study primarily pertain to the human capital, social capital, financial capital, natural capital and physical capital. In addition, we intend to upgrade the existing DFID (2000) approach to include one more form of capital such as institutional capital to capture certain characteristics linked to idiosyncrasies. These are essential in addressing country-specific issues such as government imperfections that will capture the potential risks affecting these assets would be assessed in terms of loss of output, income or value of the asset. We also use as benchmark the poverty line of the Central Statistics Office (CSO (2011)) to track current and potential departures from this figure and hence assess whether the fisher could ensure sustainable livelihoods in the near future.

We describe further below the various forms of capital and their characteristics that this questionnaire will track in the computation of the index.

Human Capital will capture household characteristics such as age, gender, educational attainment, family size and composition, nature of employment, income profile, experience, health aspects etc. Here, we intend to analyse aspects of redeployability and need for VRS (Voluntary Retirement Scheme) in order to reduce environmental stress. Also, whether a fisher could improve his livelihoods through VRS if too old or be redeployed in a more prospective sector if rather young and has reasonable skills or be trained.

Social Capital will entangle social networking aspects, such as whether the fisher is a member of any NGO, non-profitable, charitable or benevolent association, what activities are organised and what are the benefits of such association. Here we should be able to find whether he could be assisted financially or socially (in kind) from his neighbourhood. What is the possibility of pooling capital and starting a business venture or how could risks and uncertainties be shared and absorbed in a less stringent manner than depending on self?

Financial capital refers here to the savings status, indebtedness, nature of indebtedness, possibility of holding shares in companies or owner of income-generating assets etc. This remains a major factor. High indebtedness especially long term loans may lead to further depletion of the natural capital (marine environment) – a burden for future generations. Current livelihoods would as well be severely affected due to this. Lack of savings would indicate the inability to provide more comfort, education and other needs of the future generations. This would reflect unsustainable fishing practices as well as livelihoods.

Natural capital will entail uses of natural assets for commercial purposes or income generating. This will also wrap up uses of land, sea, water and forestry resources for income generation. Nature of farm, crop and output generated and their characteristics will be assessed and evaluated as well as genuine assets. In this context, we are trying to find out escapes from current status to diversify the range of income through farming and agriculture. In addition, we also assess the degree of severity of current

fishing practices and how these could be detrimental to future generations as well as current ones based on the remaining years to continued fishing.

Physical capital relates to the property held by the household (fisher), owner-occupier or not, size and quality of land, size and quality of house, age of house and its structure. Ownership rights and value of current property would provide us with insights through the possibility of using collateral assets to renegotiate a loan on a longer term or for a more profitable venture. It also signifies the ability to raise revenue for other purposes like investing in children's education rather than the need to buy land and/or build a house thereby compromising their educational and training needs.

Aspects of institutional capital have been added to track the imperfections that may exist in the current laws and policies of the local and/or central government. We wish to track as well the vision of the government in terms of protecting the environment while at the same time highlighting governance issues and financial constraints or short-sightedness.

The Sustainable=Livelihoods methodology will help to greatly assist in analyzing the immediate and medium to long term vulnerability of the coastal inhabitants. Decomposition of their assets will help to ascertain their potential degree of resilience and scope to reduce their vulnerability if ever they were exposed initially.

### **3.2 Selection of the Four Villages**

As earlier indicated, four villages, namely, Pointe aux Piments, Case Noyale, Rivière des Gallets and Quatre Soeurs have been surveyed. 422 interviews were undertaken and the breakdown is discussed later. The choice of these four regions relies on a priori knowledge (see UNDP (2008)) where GIS maps are provided to indicate how the different regions in Mauritius could be affected by floods, storms and wave surges as well as water shortages due to their physical characteristics. Pointe aux Piments is a coastal village in the North West of the island which is prone to wave surges especially when tropical cyclones move along the western coast from North to South. There are also many built-up areas that lie very close to the beach there. This region is

also affected by extreme dry summers whereby water shortages become acute and this tends to affect many planters who are based in this village. Case Noyale is another village which is highly exposed to sea-level rise and storm surges. It has many built-up areas along the coast including residential buildings. This is also a village which receives the lowest rainfall during the year and small farmers as well as inhabitants in general there suffer from regular and now increasing water cuts. Yet another village which is highly exposed to extreme weather is Rivière des Gallets. This village also lies on land which is equivalent to normal sea-level. Any atmospheric perturbations that move the waves in this corner of the island in either summer or winter or both would flood the houses located by the side of the road. People tend to suffer from serious damages caused to their houses as well as to stored foodstuffs during such episodes. Lastly, Quatre Soeurs village was considered on the basis that there is often intrusion of sea water in the cultivation of onions along the coastline leading to output and income losses. There are as well small farmers located in this region. Landslides are found to have become a recurrent feature of this village thus causing enormous damages to property and cultivation especially located at the foot of the mountain.

All in all, these four villages encompass problems related to economically disadvantaged communities, small scale farming and agriculture, low skills and squatting of public lands, amongst others.

### **3.3 Collection of Data and Information**

Existing documentation and data with respect to climate change has been the starting point in reviewing current literature and empiricism pertaining to island economies and that of the Republic of Mauritius in particular. Data collection and information gathering were done in four folds, namely, through desk research with respect to published sources and interviews at three stages. The first stage involved the interviews with key informants, the second one with inhabitants and members of locally based associations at the village level, and third one was the actual survey of the inhabitants of the four villages.

#### *3.3.1 Key Informants and Focus Groups*

Interviews of key informants from various ministries and organizations were undertaken to tap on any documentation or study relating to Mauritius. The various

organisations contacted were Ministry of Environment and Sustainable Development, Ministry of Tourism, Ministry of Agriculture, Ministry of Fisheries, National Parks and Conservation Department, Tourism Development Authority, Central water Authority, Irrigation Authority, Village Councils, Albion Fisheries Research Centre, Mauritius Oceanic Institute and Mauritius Meteorological Services. These institutions have provided the team of researchers with some documentation that has been published with respect to climate change as well as any national plan of action that the Government of Mauritius wishes to implement or adhere to within context.

Focus groups were undertaken in three villages, namely, Pointe-aux-Piments, Case Noyale and Quatre Soeurs. These were organised by the Village Councillors essentially and held at the Village Halls found in these localities. On average 12 people attended each Focus Group and participated in these discussions and they had varying profile, namely, fishers, farmers, self-employed, government and private sector employees with varying age-groups. Women did also participate in these discussions as well as some relatively younger members of the communities. The focus groups indeed enabled the research team in designing of the questionnaire and in better understanding the physical and demographic characteristics of each of the selected villages.

### 3.3.2 *Sample Size Selection and Use of Enumeration Maps*

We have used the population statistics provided by the CSO emanating from the Census conducted in 2011 to derive our sample for the four villages. A random selection was then done of the households to be interviewed based on the Enumeration Maps provided by the CSO and that are currently used for surveys by the latter. Fieldworkers were also monitored in order to ensure that each sample reflects the population at large thereby controlling for demographic characteristics, economic profile and other relevant characteristics pertaining to this survey. The following table represents the breakdown of population as provided by the CSO that was used for the sampling frame:

**Table 3. 1: Actual Population of Coastal Villages Involved in Fieldwork**

Coastal Village	Actual Population		
	Total	Women	Men
Case Noyale	499	242	257



<b>Pointe aux Piments</b>	3930	1939	<b>1991</b>
<b>Quatre Soeurs</b>	2145	1041	<b>1104</b>
<b>Riviere des Gallets</b>	573	293	<b>280</b>
<b>Total</b>	<b>7147</b>	<b>3515</b>	<b>3632</b>

Based on Confidence Intervals of 95% and 99%, it was found that the actual number of interviews to be carried out was 364 and 608 respectively, and the corresponding number of men and women respondents should be 179 and 185 and 299 and 309 respectively. However, as per actual field work done and using the 95% Confidence Interval with an error margin of 5%, the number of interviews considered as valid being 422, of which 265 were male and 157 female respondents. The choice of 95% was done because of cost implications and the time frame to complete the project. Further deviations from the critical values were due to adjustment done to encompass certain demographic characteristics while preserving normality assumption of certain attributes.

**Table 3. 2 : Profile of Respondents by Gender**

<b>Villages</b>	<b>Male</b>	<b>Female</b>	<b>Total</b>
<b>PAP</b>	167	68	235
<b>QS</b>	56	50	106
<b>CN</b>	23	18	41
<b>RDG</b>	18	22	40
<b>Total</b>	264	158	422

The above table shows the break-down of male and female respondents from the four villages individually. Since Pointe aux Piments has a much larger population, it gets automatically picked up as the largest representation in the sample.

**CHAPTER 4:**  
**DATA ANALYSIS AND FINDINGS**

**4.0 Introduction**

This section provides enormous insights into the responses by the interviewees that emanate from the survey carried out in the four villages. The data analysis is broken down into general descriptive statistics and key findings related to sustainable livelihoods related to climate change. Further analysis of vulnerability is addressed in the forthcoming chapter.

**4.1 Some Descriptive Statistics**

- Age Profile and Marital Status

Our sample consisted of 422 interviews held in the regions of Case Noyale (CN), Pointe aux Piments (PAP), Quatre Soeurs (QS) and Rivière des Gallets (RG). The age profile of the respondents is shown below:

**Table 4.1 a - Age Profile**

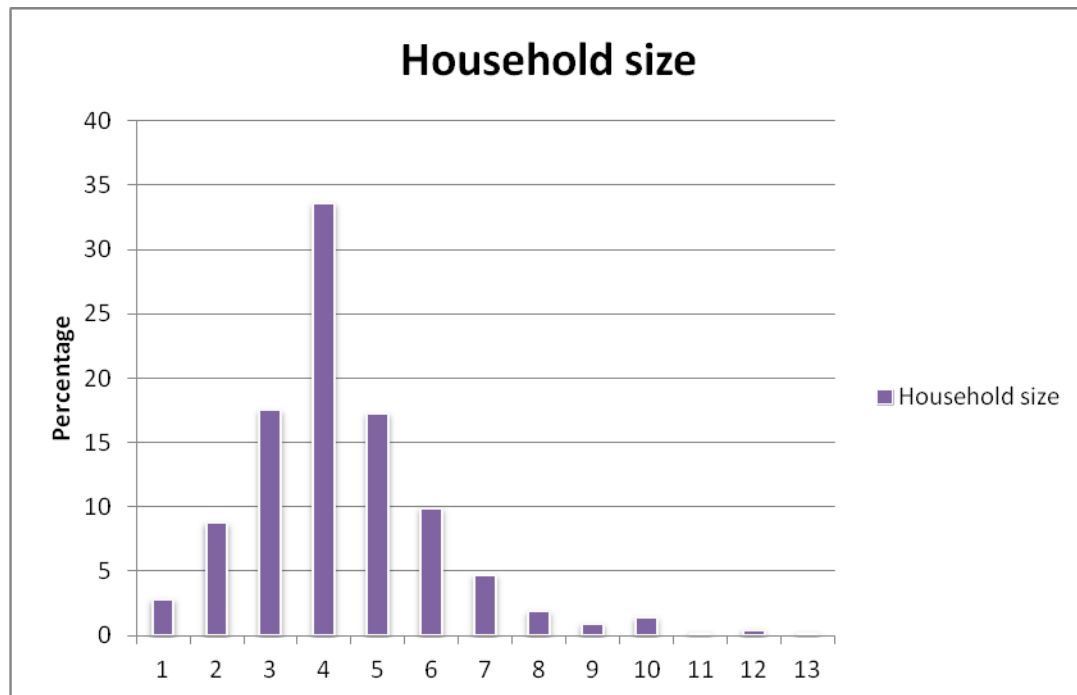
Age	All villages (%)	CN (%)	PAP (%)	QS (%)	RG (%)
<b>0-20</b>	1.4		1.3		10
<b>20-40</b>	43.8	58.5	39.5	47.2	32.5
<b>40-60</b>	43.8	34.1	47.6	43.4	52.5
<b>60-80</b>	10.4	7.3	11.6	9.4	0.5

Most of our respondents 87.6% fall into the age-group between 20 and 60, constituting the active population of the island. Out of this sample, 62.1% were men and 37.9% were women respondents. The lower percentage among women in these coastal regions is basically attributed to the fact that most of the households are headed by men and those who hold a formal job. Moreover, 68.5% of these respondents were married while 21.3% were unmarried, the rest (10.2%) were divorced, widowed or separated. When we look at villages individually it can be

noted that in the case of CN more than 50% respondents were in the age group of 20-40 and non from 0-20 as in the case of QS.

- *Household Size and Educational Attainment*

Coming to household size, the chart below relates that most of the highest percentage clustered around a family size of 4.



**Fig. 4.1 ( a): Household size**

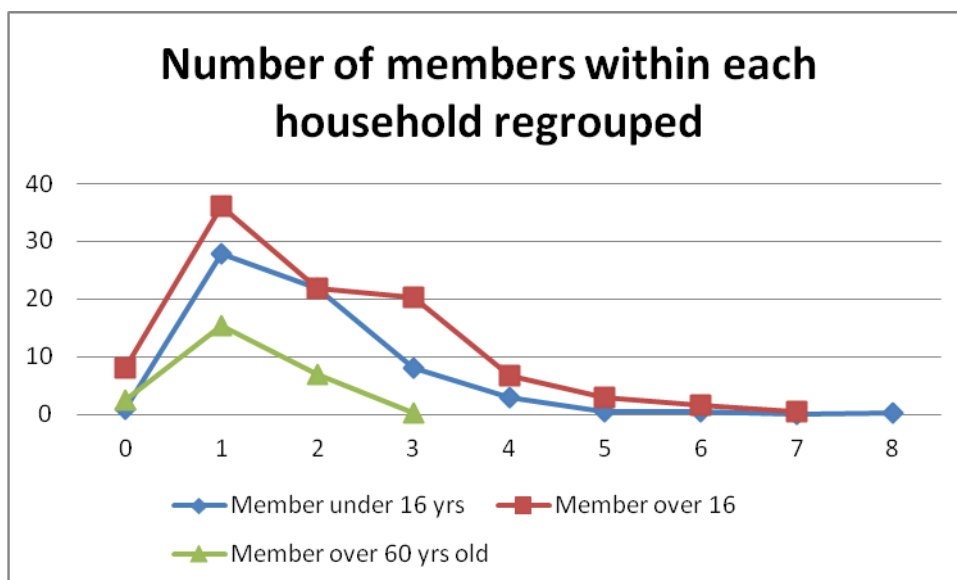
There were 12 single-headed households and 1 household whose family size is equal to 13 in number. In fact across 157 households, it was found that the family size exceeded 4 members. The higher the family size, the more dependents. Of these we could see that most of the respondents have studied up to and including secondary level education, while a few, 5.4%, has never been to school at all. This is illustrated in the table below:

**Table 4.1 b - Educational Attainment**

Education Attainment	All villages (%)	CN (%)	PAP (%)	QS (%)	RG (%)
Never been	5.4	9.8	3.8	6.6	7.5
Primary	41	41.5	38.7	43.4	52.5
Secondary	46.4	43.9	47.7	46.2	37.5

<b>Technical</b>	1	2.4	0.9		2.5
<b>Diploma</b>	1	2.4	1.3		
<b>Tertiary</b>	5.2		7.7	3.8	

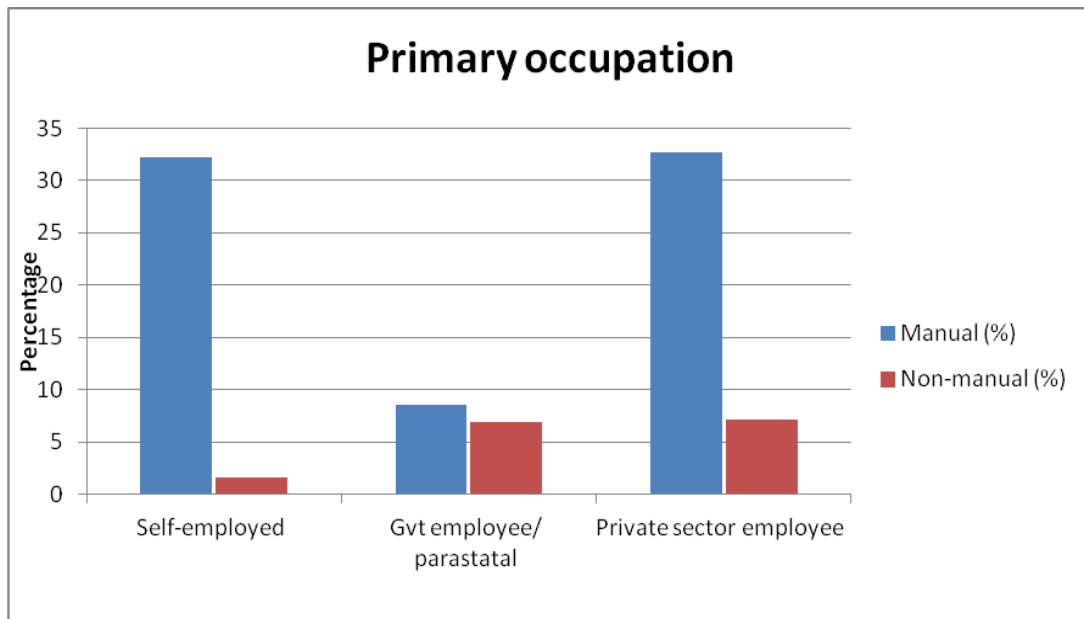
It is also worth noting that 5.2% of the sample have studied beyond secondary level of education to pursue university education. Out of the four villages interviewed only in PAP and QS we had some respondents with tertiary education and it can be further noted that in CN we had the highest percentage of respondents who has never been to school. Furthermore, there were 251 members of the family interviewed who were below the age of 16 and 105 above the age of 60. This would mean that 62% and 25% approximately of the households interviewed have at least one member with the age of 16 and below, and with the age of 60 and above respectively. This is also shown below:



**Fig. 4.1 ( b): Household members**

- *Employment Profile*

33.9 % of the respondents work for themselves, 15.4% work for the public sector while 51.7% work in the private sector and the divide between manual and non-manual jobs performed by the respondents is 73% and 27% respectively. Thus most of the people interviewed in these four villages are involved in agriculture, farming, fisheries and do perform low-skilled jobs. This is illustrated as well in the graph below:



**Fig. 4.1 ( c): Primary Occupation**

A brief look at the statistics reveals that the number of respondents being self-employed represents at least 30% of total employ respondent in each village.

- *Health Status*

When it comes to the health status of the inhabitants, 81% were found to be in good health while 19% suffer from some illness. Out of these 19%, 54.1% were found to suffer from illnesses that are not serious, while 14.75% were considered as very serious and 31.15% not so serious. In CN, 50% of the respondents claimed that they suffer from acute illness. It was also reported that 75.8% of the respondents indicated that no other member of the family was suffering from any illness. Most of the people who were found to be unwell suffer from diabetes, high blood pressure and quite a few of them suffer from asthma and stomach disturbances. Regarding health care expenses, it was found that the interviewers have reported rather varying figures as indicated below.

From the table below, it can be deduced that 50% people interviewed do spend at least Rs 4000 per annum, and of which 35.2% would spend at least Rs 6000. From the four villages surveyed, CN comes out first on lowest health care expenditure (30.56%), while QS comes out first as the highest percentage of people spending an amount above Rs 6,000 on medicare. 79.4% of the respondents indicated that they had no medical insurance and even on a case to case basis the statistics from each village

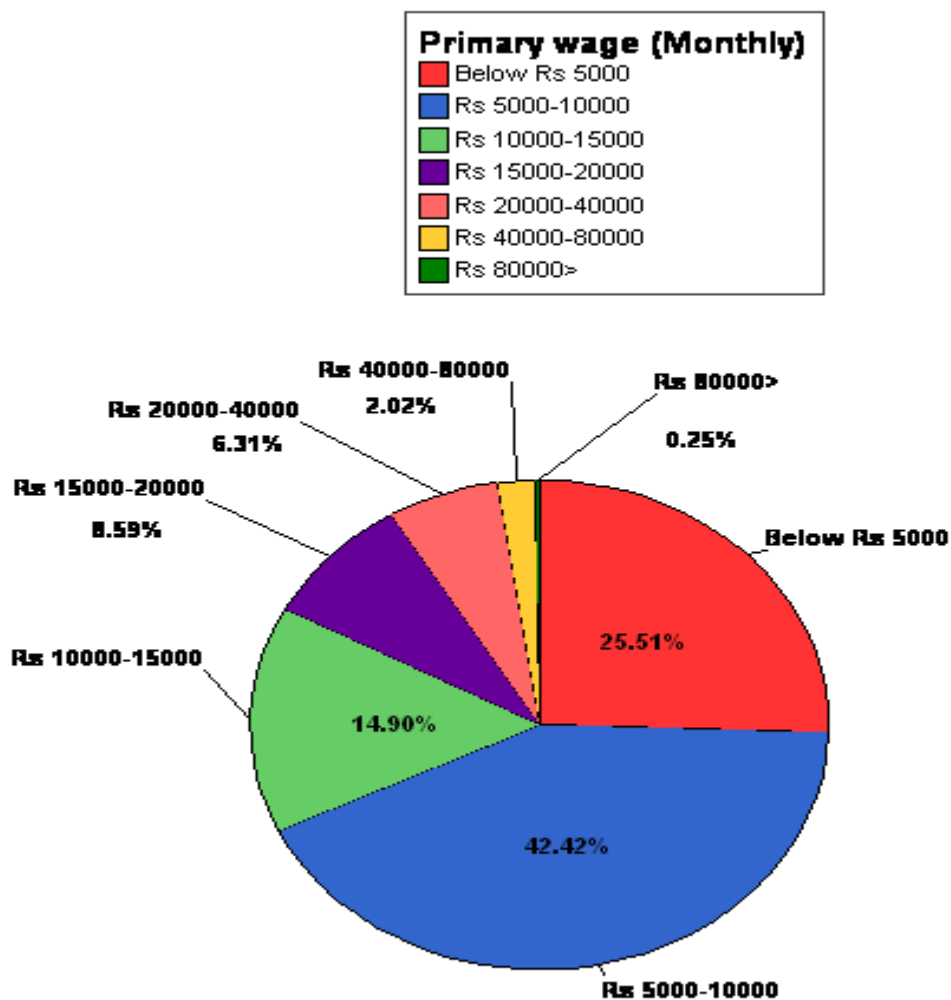
reveal the same trend. Data from all villages disclose that 47.5% of the respondents suffer from illnesses that are linked to extreme climatic conditions and 45.2% have to be absent from work as a consequence of poor health conditions. Among the four villages we found that in QS more than 50% (60%) of the respondents declared that their labour absenteeism was due to their illness while in the other villages the figures were lower.

**Table 4.1 c - Cost on Health care**

Health Care	All villages (%)	CN (%)	PAP (%)	QS (%)	RG (%)
Rs1000-2000	26.22	30.56	24.17	23.81	40
RS2000-4000	23.91	26.78	22.75	30.48	8
Rs4000-6000	14.65	11.11	18.48	9.52	11
Above RS6000	35.22	30.56	34.60	36.19	41

- *Income Status*

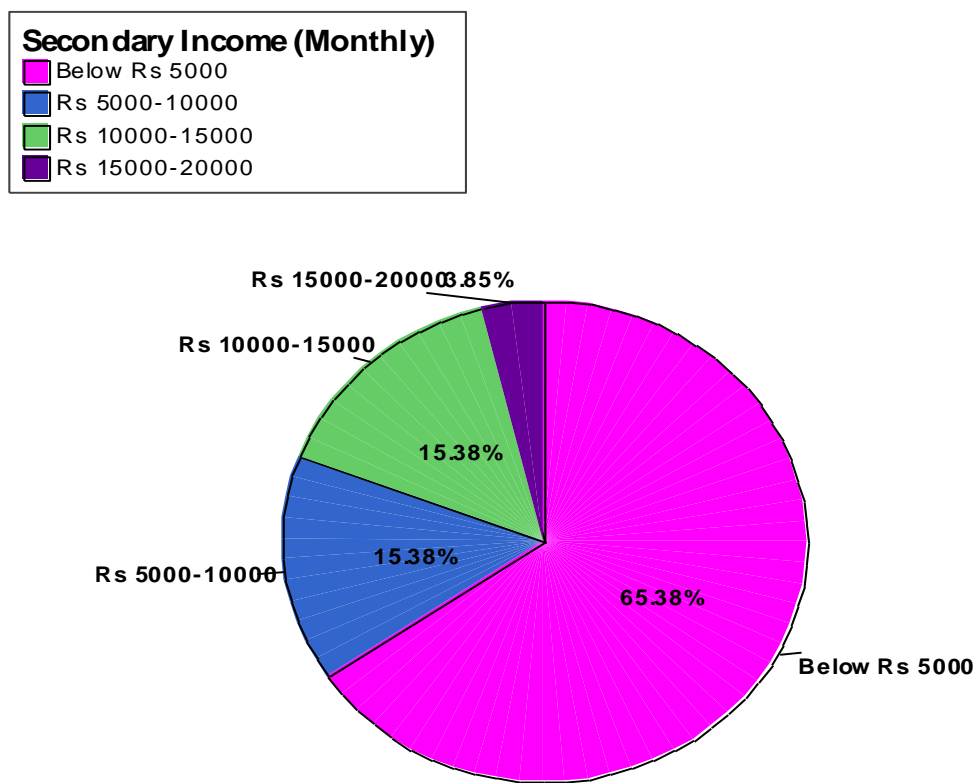
The following two charts provide information with respect to the income of the interviewees:



**Fig. 4.1 (d) Primary Wages**

Primary income level obtained by the respondents from the manual and non-manual jobs performed represented in different ranges is depicted in the above pie-chart. There are 25.51% people interviewed who reported that their primary income is below Rs 5,000 a month (below than the poverty line set by the CSO of Rs 7,320 per month), while 2.27% of them claimed to be earning at least Rs 40,000 a month. The biggest chunk of people, 42.42%, earns between Rs 5,000 and Rs10, 000 a month. The outliers in terms of extreme income (beyond Rs 80,000) come from the two villages PAP and QS while in all the four villages the majority of respondents receive an income ranging from Rs 5,000- 10,000.

Many of the respondents perform more than one job especially those who are highly unskilled. When the additional income is considered, an improvement in the financial status of the respondents is observed. If we consider only the primary source of income, it would be seen that the 25.51% of the respondents would not even make it for the ½ median income of Rs 7,320 in the year 2007. In both RDG and PAP none of the respondents has a secondary source of income which on a priori gives an indication about their financial vulnerability while in QS secondary jobs of respondents were mainly animal rearing and cultivation.



**Fig. 4.1 (e): Secondary Income**

#### **4.2 Findings Pertaining to Climate Change**

- Climate change awareness and its consequences



By and large, respondents have indicated that they are aware of all the potential changes that are occurring or how the climate may further change in future. What could be observed, in particular, is that these people may believe that any extreme event is bound to occur based on their recent experiences about droughts, cyclones and floods as well as very warm summers and cool winters. Hence, they may not realise the frequency that such extreme events may occur nor their consequences as discussed later. To cite an example, not many people might have perceived that sea-level rises could also occur and is thus a climate change phenomenon. Mostly fishers and amateur fishers and some planters did reflect on this issue. The various responses are given below:

**Table 4.2 a - Climate Change Awareness**

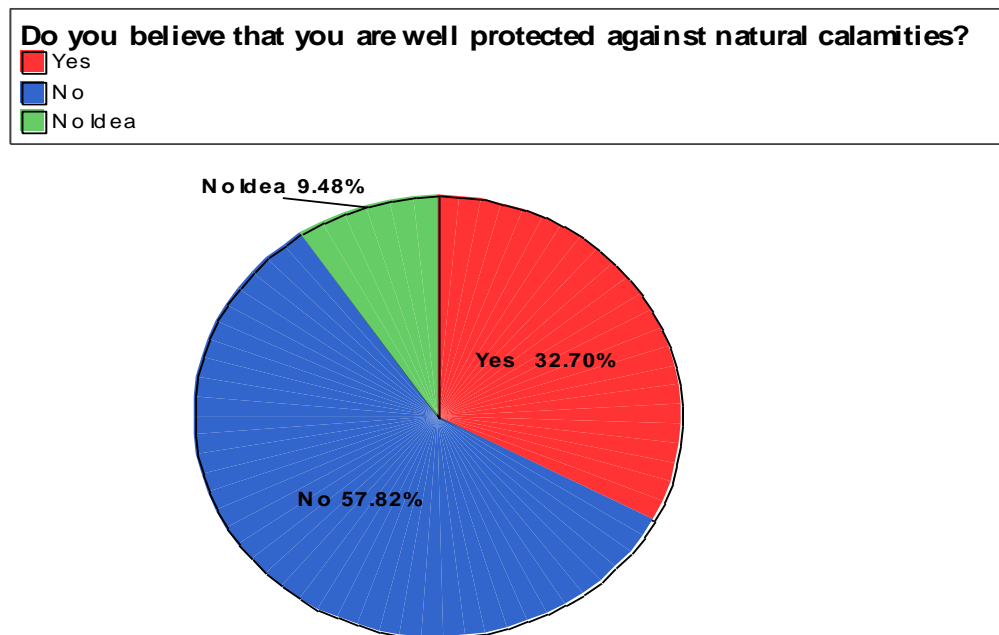
Climate change	Yes (%)	No (%)	No idea (%)
<b>Sea -level rise</b>	70.1	10.4	19.4
<b>Hotter in summer</b>	92.9	4.7	2.4
<b>Colder in winter</b>	77.7	19.2	3.1
<b>Coral bleaching</b>	59.2	6.9	33.9
<b>Frequent flooding</b>	26.2	33.2	10.7
<b>Drought</b>	87.9	7.3	4.7
<b>Changes in cyclonic pattern</b>	77.5	11.6	10.9
<b>Changes in sea water currents</b>	54.5	5.5	39.6

With respect to the consequences of climate change, it was found that respondents have shown an extremely high level of awareness, especially in inflated prices. The latter may be attributed to the average vegetable price hike that occurs after any extreme weather episode namely, flooding, drought or passage of a cyclone, has occurred. We also noted the high response of people in recognising the effect of changing weather conditions of their health. On the other hand, it is found that the response to climate change affecting housing structures was the lowest, 63%, indicating that people generally believe that today houses are mostly made of concrete and have adapted to extreme weather conditions, with obviously a few isolated cases in certain areas. The situation is much more different compared to the 1970s and earlier.

**Table 4.2 b - Effect of Climate Change**

Effects of climate change	Yes (%)	No (%)	No idea (%)
Reduction in fish stocks	83.6	6.6	9
Reduction in livestock	84.8	7.3	7.3
Reduction in crop production	82.2	13.5	3.6
Higher prices in general (inflation)	95.5	3.3	0.5
Affect the health of people	90	4.7	5
Affect housing structures	63	16.6	19.9
Affect quality of life	88.6	6.2	5.2

Respondents were asked whether they are in security against climate change as far as their houses are concerned. Their responses are shown below:



**Fig. 4.2 ( a): Security against Climate Change**

The responses indicate that 57.82% felt that they are not protected while 32.7% openly confirmed that they are protected while 9.5% had no idea. The high level of insecurity is explained due to the location of their houses in a costal zone, threatened by tsunamis, flooding, high tides, landslides, their houses are not strong enough and threats of electric poles falling down during cyclonic conditions as well. In addition, 45.1% of the respondents claimed that their mobility and displacement are affected

because of flooding in the yard, lack of transport, damaged roads and poles that have fallen down with electrical wires lying on the ground.

### **BOX 1: Probit Regression on Security of Households Against Climate Change**

*Probit Regression on Security of Households Against Climate Change:*

*The following binary regression was run to ascertain the main factors that could determine household security against extreme weather;*

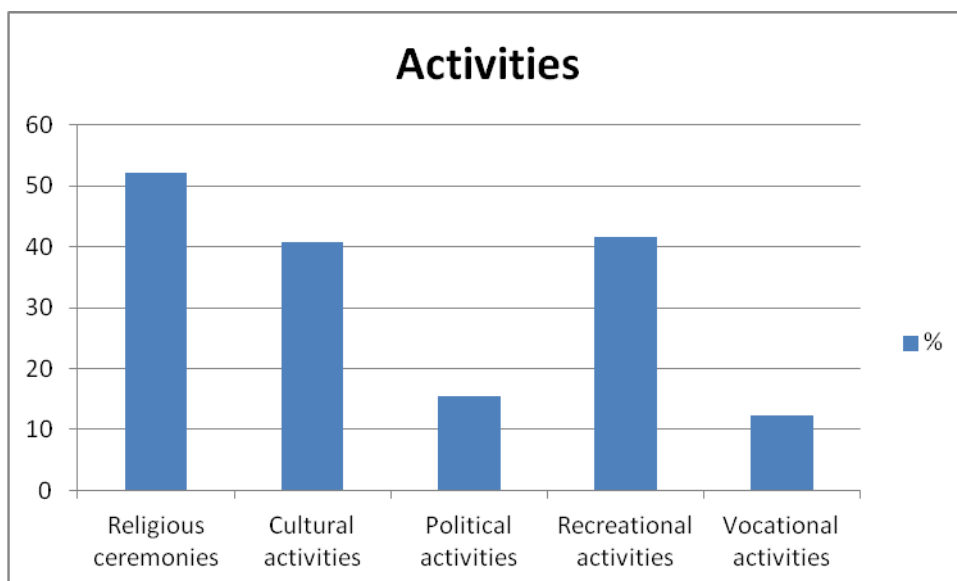
$$R = f[A,G,M,E,S,O,ST,I,Y]$$

*R = Binary Response (Yes or No) of Being Secure or Insecure, A = Age of Household, G = Gender of the Household, M = Marital Status of the Household, E = Education Status of Household, S = How Socially Active is Household, O = Ownership of House by the Household, ST = Structure of the House (Its Strength), I = Investment (Wealth variable) and Y = Income of Household*

*When this regression was run with 409 observations, it was found that A, S, ST and I were significant factors that determine the responses. They all had positive and significant signs indicating the feeling of security varies directly with age; the older the household, the more active he is socially, the more robust (concretely built) is his house, and the wealthier the household. The level of significance of these variables varied from 1% to 10%, Age being the most significant explanatory variable.*

- Aspects of Social Capital

Data collected indicate that respondents are generally in good terms with their neighbours. Any disagreement is due to issues linked with property rights or personal problems. Moreover, it is also found out that people do trust their relatives as well as friends and certain neighbours. 63% of the people interviewed are found to be socially active. They are most socially active in doing religious activities (52.1%) and least in vocational ones (12.3%).



**Fig. 4.2 ( b): Participation in social activities**

There are members who are part of certain associations that do cater for climate change and environmental activities but the rate is very insignificant. Altogether, they might be contributing a small amount as charitable fund but do not get anything substantial in return especially during natural hazards.

### **Box 2: Some General Facts Reported During the Focus Groups**

*Some general facts reported during the Focus Groups:*

- *In Pointe aux Piments, for instance, it was reported that there are at least 100 houses that could potentially be inundated based on past recent experiences about flooding*
- *In all the villages, it is mentioned that public water drains must be restructured and better maintained as they cause a lot of flooding due to heavy rains*
- *It was also revealed that there are no irrigation facilities for small planters in the regions of Pointe aux Piments and Quatre Soeurs where agriculture is practised more than the other villages surveyed*
- *NGOs are found to be present in all the villages and there are local associations that work towards the welfare upliftment of local citizens. However talks on climate change and awareness campaigns are remote*
- *The lagoons are reported to be undergoing constant degradation due to more environmental pollution. Hotel development and improper waste collection methods have exacerbated the problem of coastal and marine pollution, thereby affecting adversely marine ecosystem*
- *There are many people who are found to suffer from allergies and especially among children this is more widespread*
- *Mosquitoes are becoming increasingly a big problem*
- *Landslides seem to be a major concern of Quatre Soeurs village. During the last flooding, 11 houses were affected. Government is helping the affected parties to find a solution*
- *Village council does help a lot along with local associations to clean the village and to help affected households during flooding or after the passage of a storm*

- Aspects of Physical Capital

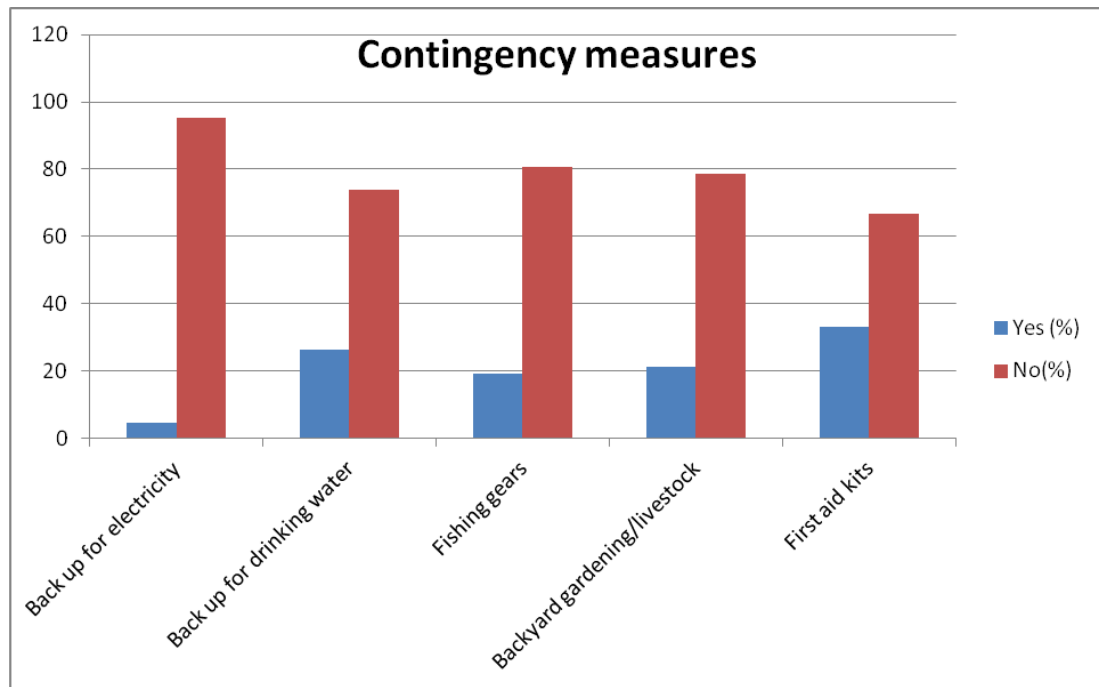
69.2% of the respondents have been found to own their house while 3.1% do pay a rent as tenants. The amount paid varies from Rs 50 to Rs 1200 per month. The low rental rate is attributed to rent land or a house on a bail basis. This rent is highly subsidised by the government. Regarding the strength of the house, 77.6% people have indicated that their house is built fully of concrete, while the remaining indicated that theirs' are either made of iron sheets or wood or both of these materials. In addition, these houses were observed to be fully equipped with the necessary amenities and the table that follows provides information to that effect:

**Table 4.2 c - Amenities**

Amenities	Yes (%)	No(%)
Water	98.1	1.9
Electricity	98.6	1.2
Mobile	65.6	33.9
Telephone	81.3	18.7
Internet	35.5	64
Land vehicles	52.1	47.6
Boat	8.1	91.7

Most of the respondents do possess water and electricity as indicated in the above table, while more than 65.5% of them own a mobile phone and 35.5% have got internet connectivity. Land vehicles owned include motorcycles and bicycles as well. Those who do not have water and electricity are essentially squatters or have no legal status to own a house and land.

Most respondents are found to have some contingencies measures related to extreme weather conditions. These are again shown below:



**Fig. 4.2 ( c ) : Contingency measures**

While most the people generally do not have generators to cater for power cut as reflected here, it is rather surprising to find that quite a few respondents do not have any water storage facilities. A much lower percentage was found not to have any first aid kits at home. We also note that some people might be still cooking using wood (17.5%) and coal (0.5%).

82.38% of the respondents are found not to possess land elsewhere and 91.23% have never taken shelter under a cyclone-refugee centre while most of them who did so was during the passage of a cyclone or during flooding. Households were also asked about the changes in climatic conditions that they might have observed or experienced over past 30 years or less. Their responses are given below:

**Table 4.2 d - Climatic changes over the past years**

Climatic changes	Yes (%)	No (%)
Tropical cyclone	94.8	5.2
Storm	88.8	15.2
Coastal/beach erosion	77.1	22.9
Drought	96.4	3.6
Flooding	71.6	28.4
Sea-level rise	72.6	27.4

Sea surface temperature	57.8	42.2
Hotter in summer	97.6	2.4
Colder in winter	95.7	4.3
Land/mud slide	33	67

People have revealed that summers are getting hotter while droughts are becoming more frequent. Observations pertaining to land-slides are much lower as the latter could be specific to a given region, namely, at Quatre Soeurs. In addition, interviewees were asked about the evolving effects of climate change on the family and the following responses were made:

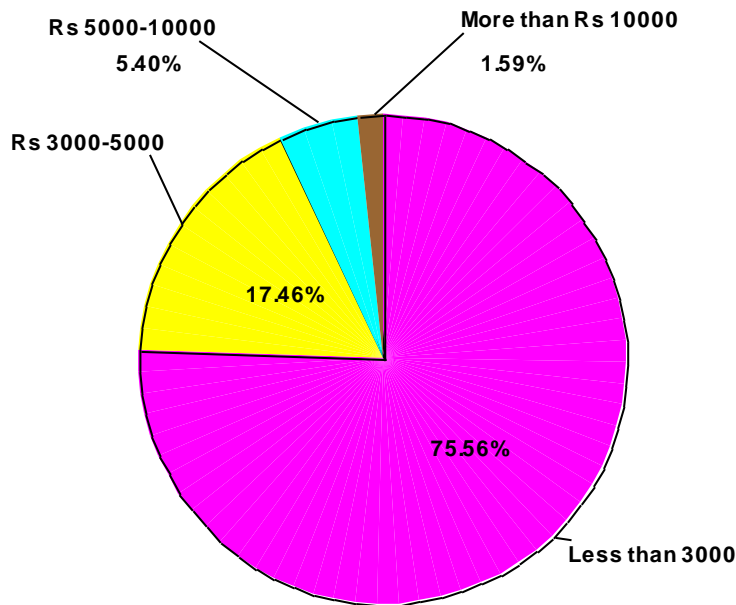
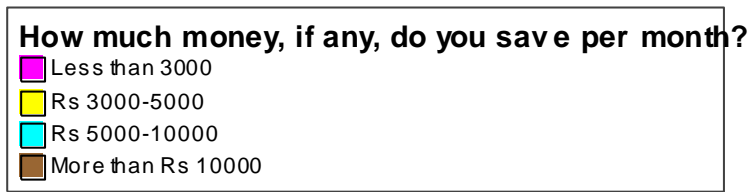
**Table 4.2 e - Impact on household**

Impact on household	Low (%)	Medium (%)	High (%)	No Idea (%)
Tropical cyclone	48.1	22.8	25.6	3.6
Storm	45.7	21.1	20.9	12.3
Coastal/beach erosion	50.1	18.7	21.2	9.7
Drought	17.3	16.6	63.6	2.5
Flooding	38.5	22	36.5	3
Sea-level rise	40.7	15.6	33.1	10.6
Sea surface temperature	46.5	17	26.1	10.4
Hotter in summer	8.9	6.4	83.7	1
Colder in winter	30.3	11.9	56.1	1.8
Land/mud slide	39.6	19.8	37.6	3

Here again it would be observed that hotter summers and droughts seemed to be a major problem for the respondents in general. 97.4% of them have also indicated that they did not have to dispose of any asset due to an extreme climate event.

- Aspects of Financial Capital

44% of the respondents were found to be indebted. These are guaranteed loans taken over an average period that exceeds normally 5 years. Such loans have been contracted against collateral assets from commercial banks. Moreover, there are short term loans contracted from family members for transactions purposes such as marriages, financing education of children and meeting contingencies related to businesses. In addition, respondents were asked about the amount saved by them and their responses are given below:



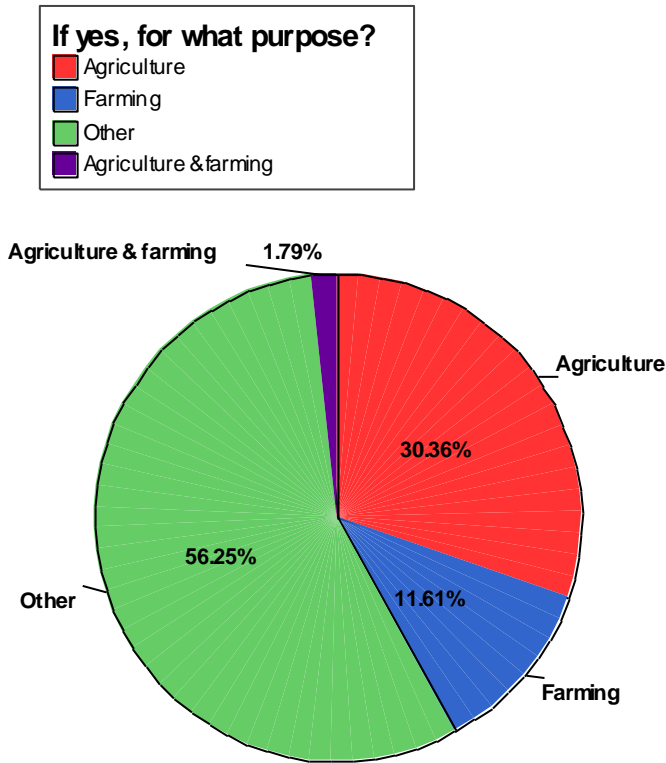
**Fig. 4.2 ( d): Amount Saved per month**

About 76% of the respondents claimed that they do save an amount which is less than Rs 3000, while 17.5% revealed saving between Rs 3000 and Rs 5000, while some 5.4% indicated that they do save an amount between Rs 5000 and Rs 10,000 and finally the smallest group of 1.6% revealed that they can save more than Rs10,000 per month. Furthermore, 96.7% of the people interviewed indicated that they do not hold any other investment asset as wealth apart from their private savings. Coming to business activity, only 5.2% indicated that they are involved in joint ventures. The business-related activities undertaken relate to informal jobs such as artisanal works, amateur fishing, selling cakes and fast-foods amongst others. 86.8% of the people interviewed revealed that they have not inherited from any wealth from their ancestors and have started their business activity and socio-economic life on their own.



- Financial Capital

76.1% of the respondents have revealed that they do not use their land for any commercial purpose. While the remaining do confirmed the following:



**Fig. 4.2 ( e): Commercial purpose**

43.75% of the respondents are involved in businesses that are related to climatic conditions. Out of this, 30.36% are involved in agriculture alone. Only a few of them have diversified their output to include farming. Those who do farming reared ducks, chickens, cattle and goats amongst others. Obviously, 84% of the people holding these businesses claim that their activity is directly related to climatic variations.

We can see further below how climate change is perceived to affect these businesses:

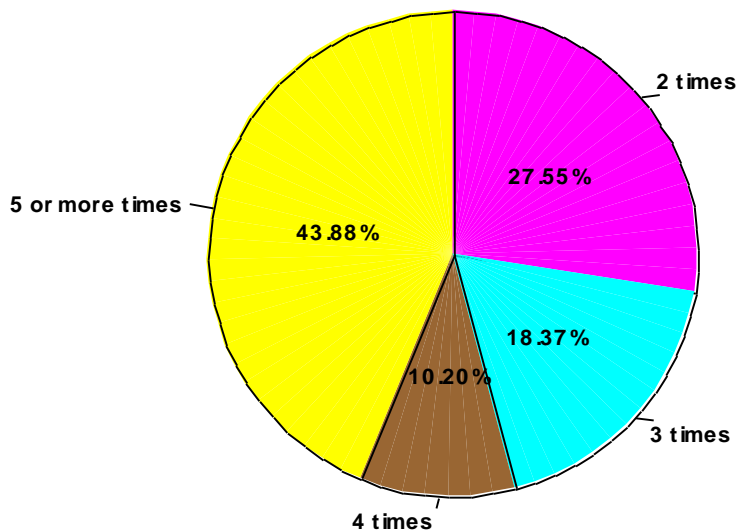
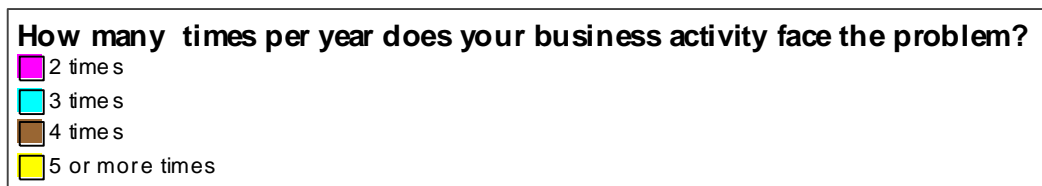
**Table 4.2 f - Business affected by climate change**

Column1	Low %	Medium %	High %	No idea %
<b>Tropical cyclones</b>	6.1	6.1	86.1	1.7
<b>Storm</b>	28.2	12.7	29.1	30
<b>Drought</b>	30.3	11.9	52.3	5.5

<b>Flooding</b>	22.4	10.3	57	10.3
<b>Salt water intrusion</b>	31.6	1.6	17.2	43
<b>Insect attack</b>	16.9	16.9	48.2	18.1
<b>Soil erosion</b>	34.7	8.3	27.8	29.2
<b>SLR</b>	15.9	17.5	50.8	15.9
<b>SST</b>	25.4	16.9	35.6	22
<b>Coastal erosion</b>	23.7	20.3	35.6	20.3
<b>Coralbleaching</b>	16.9	6.8	54.2	22
<b>Mud/land slide</b>	47.7	25.6	8.3	25

This table clearly shows that greatest adverse effect on these businesses seems to be caused by tropical cyclones, droughts, flooding and insect attacks. In certain cases, sea-level rise seems to be quite a problem especially if crop land is located very close to the sea like in Quatre-Soeurs. On the other hand, coral bleaching would have a direct effect on fish migration and as hatching grounds, the disappearance of corals would pose a threat to fish habitats. The disappearance of mangroves as well in many areas due to human activity has greatly exacerbated the degradation of the coastal and marine environment.

Altogether, it is found that those who hold such businesses have noticed a marked deterioration in the output of their businesses since the last 5-10 years. The frequency that such effect is felt is shown in the diagram below:



**Fig. 4.2 ( f): Number of times business affected**

Most of the respondents (44% approximately) who hold these businesses indicated that the impact is being felt at least 5 times per year, while 27.55% reported that this impact was felt only 2 times a year.

It was also reported that 22% of the respondents realised a monetary loss of spreading from Rs300 per day to Rs 1000. Others have reported having lost approximately Rs 500,000 over the past 5 to 10 years while 8% claimed to have lost more than Rs 25,000. The following pie-chart summarises the expectations of business owners while anticipating even greater deterioration of climatic conditions. About 58% of them anticipate that the situation would change from bad to worse, indicating even bigger losses in the near future. However, when the concerned respondents were asked whether they have considered new or alternative business strategies to overcome the expected losses, only 17.92% have answered positively. The rest either have no idea (42.45%) or have not given any thought about it (39.62%). Those who have answered positively have revealed that they need to diversify their crop,

strengthen their farms, use irrigation techniques or more efficient ones and even change their business venture as mitigating strategies.

The following table reveals the perceptions of respondents with respect to certain features of the natural capital;

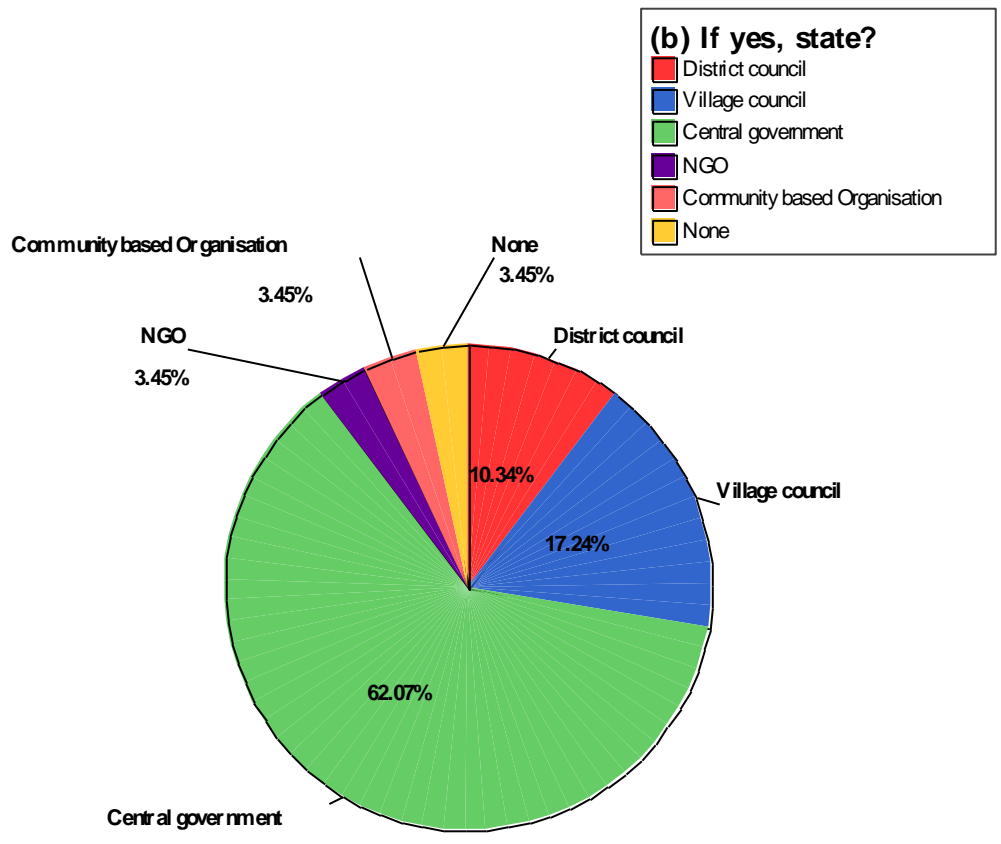
**Table 4.2 g - State of Natural Resources**

Bad State	Mangroves	Corals	Fresh water	Upland forests	Seagrass	Wetlands	Other e.g soil quality
<b>Low %</b>	5.9	2.4	8.3	8.1	1.6	5.1	22.1
<b>Medium %</b>	13.2	12.7	17.6	15.6	14.7	12.4	26.9
<b>High %</b>	48.5	72.6	59.8	58.8	57	54.3	38.5
<b>No Idea %</b>	32.4	12.3	14.2	18.1	26.7	28.2	12.5

The degradation of corals seems to be worst compared to the others, followed by fresh water resources and upland forests.

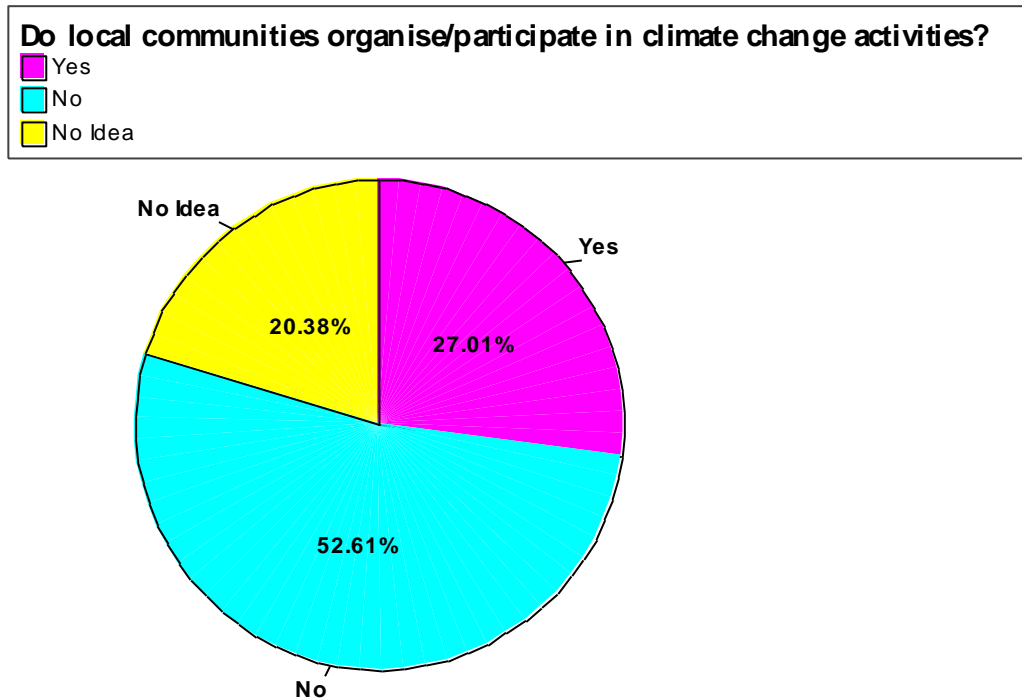
- Institutional Capital

92.6% of the respondents claimed that they have not received any form of compensation, while those who claimed that they did, 62.1% stated that they got it from the central government, 17.24% from Village Council, 10.34% from District Council and 3.5% from NGOs. Such assistance was in the form of material for construction, foodstuffs and construction materials, thus mostly in-kind transfers.



**Fig. 4.2 ( g): Institutional assistance**

There are 52.6% respondents claiming that they have never participated in talks related to climate change, while 20.4% have no idea that such talks are done.



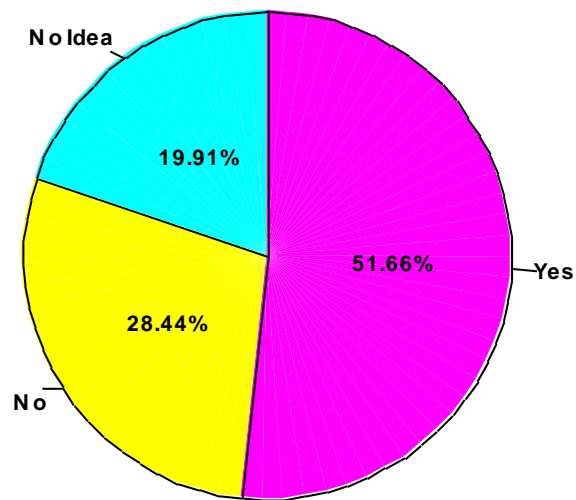
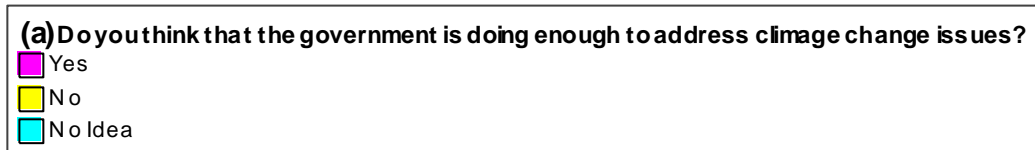
**Fig. 4.2 ( h): Participation in climate change activities**

This shows that 73% of the respondents are unaware of such talks as well as participation in climate-change related activities at the village level.

On the other hand, with respect to activities related to climate change and action being taken by the government, 52% of the respondents have indicated that government is actually doing a good job. However, there are still certain issues that need be looked into especially those who revealed that this may not be so. The various responses in line with this negative response are given below:

- To replace gabion by some other more robust and sustainable method to reduce coastal or beach erosion
- Improve financial assistance for those who are directly concerned by climate change events

- Introduce marine protected areas to allow the replenishment of fisheries resources
- Improve the drainage systems both at private and public levels
- Relocate people to areas that are less prone to climate extremes
- At local level there is very little which is done to address climate change matters.



**Fig. 4.2 (i): Views on Adaptation & Mitigation strategies of Government**

## **CHAPTER 5:**

### **IDENTIFYING THE MOST VULNERABLE PEOPLE**

#### **5.0 Defining the Most Vulnerable Individuals**

While there exist various definitions of vulnerability (see for instance Nurse (2001), Boko et al. (2007) and Cutter (1996) amongst others), this study is particularly concerned with climate change in a small island economy with very typical features as have been highlighted in the previous chapter. It is believed that the nature of the vulnerability or exposure to extreme climatic events should also have a temporal orientation. It is important to consider this aspect because exposure could be immediate, over the medium or long term. This long term will determine the extent to which communities could develop resilience. The most vulnerable individual should be someone who would be impacted immediately following an extreme climatic episode – be it flooding, storm surge or sea-level rise or drought. But the extreme events that can lead to injuries and eventual loss of human life are basically exposure to intense tropical cyclones, flooding and wave-surges especially for those who might be old and suffer from physical and mental disabilities and who might be, leaving next to and/or along the shore. Their houses might not be strongly built as well. Moreover, these people would not also be able to improve their status to become less vulnerable in the long run as they are severely financially disadvantaged and constrained. Owing to several reasons, they would not be able to raise their income and afford enough to buy land and build a house in a safe place.

The sustainable-livelihoods model is hereby important to track both the short run and long run evolution of the vulnerability of any household as it encompasses different characteristics of the household who might be at risk. Based on the criteria obtained during the survey, different levels of vulnerability can be computed and analysed. Hence, the discussion, in this chapter, is about the different forms of vulnerability which are based on the Sustainable-Livelihoods approach. These are further to address more pertinently the climate change vulnerability or those people who might be immediately concerned by natural catastrophes generally observed over and around Mauritius.



### **5.1 Vulnerability and Varying Level of Capital**

Based on the data that have been obtained during the survey, it is possible to identify the different forms of vulnerability, for instance, against financial status, wealth (human and physical) as well as social networking. Moreover, this classification can be done with respect to the individual villages as well as taking into account the gender component. This is reported in the following table:

**Table 5. 1: Varying Vulnerability with Different Forms of Capital**

<b>Human Capital Vulnerability</b>										
	Not married	Household size $\geq 3$	Suffer from chronic illness	Illness is affected by weather conditions	Age >60 years	No medical insurance	Years of schooling $\leq 6$ (primary or less)	Number of respondents		Extent of vulnerability
All Villages	✓	✓	✓	✓	✓	✓	✓	1m		High
CN	✓	✓	✓	✓	✓	✓	✓	1m		High
QS		✓	✓			✓		9m	10f	Medium
PAP			✓			✓	✓	1m	1f	Medium
RDG		✓		✓		✓	✓	4m	3f	Medium
<b>Social Capital Vulnerability</b>										
	Not in good terms with neighbours	Not member of any climate change association	Not socially active					Number of respondents		Extent of vulnerability
All Villages	✓	✓	✓					10m	3f	High
CN	✓	✓						1m	1f	Medium
QS		✓	✓					8m	11f	Medium
PAP	✓	✓	✓					8m	2f	High
RDG	✓	✓	✓					2M	1F	High

<b>Physical Capital Vulnerability</b>										
	Does not own house	Location of house exposed to threats from climate change	Does not own land somewhere-else	No contingency resources (be if for drinking water, electricity, fishing gears and backyard gardening)	House made of iron or wood			Number of respondents		Extent of vulnerability
All Villages	✓	✓	✓	✓	✓			8m	9f	High
CN	✓	✓	✓	✓				1m		High
QS	✓	✓	✓	✓	✓			1m	3f	High
PAP	✓	✓	✓	✓	✓			7m	5f	High
RDG	✓	✓	✓	✓	✓				1f	High
<b>Financial Capital Vulnerability</b>										
	Contracted Loan over the last 5-10 years	Indebted towards others	No inheritance	Primary income <5000	Secondary income<5000	Commercial activity affected by climate change	Expect loss to continue in the future	Number of respondents		Extent of vulnerability
All Villages	✓	✓	✓	✓	✓	✓	✓	1m	1f	High
CN	✓	✓	✓	✓				1m	1f	Medium
QS	✓			✓	✓			3m	3f	low
PAP	✓	✓	✓	✓	✓	✓	✓	1m	1f	High
RDG	✓			✓				5m	5f	Low

Natural capital Vulnerability										
	Perceive at least 3 out of the community natural resources ( wetland, mangroves, coral, seagrass, freshwater, uplandforest, others) to be in very bad state	Commercial activity is affected by climate change	Commercial activity which is affected by climate change at least 4 times per year	Expect loss to continue in the future	No alternative to reduce the expected loss.			Number of respondents		Extent of vulnerability
All Villages	✓	✓	✓	✓	✓			1m		High
CN		✓		✓	✓			2m	3 f	Medium
QS	✓	✓		✓				3m	2f	Medium
PAP	✓	✓	✓	✓	✓			1m		High
RDG		✓	✓	✓	✓			2m	1f	Medium

Note: High vulnerability is when the maximum score is obtained in each measurement of capital, Medium vulnerability refers to any score less than the maximum score and Low vulnerability pertains to a score equivalent to 50% of the maximum score.

#### Human Capital Vulnerability

From the above data, it can be deduced that in all the four villages, it has been found that there is one individual a male respondent, could be considered under 'Human Capital Vulnerability', as highly vulnerable, based on the criteria that are shown in the table itself thereby threatening his livelihood in the long run. The characteristics considered are they are unmarried, the family size is more than 3 to reflect the presence of dependent members, they suffer from at least one chronic illness, which is also affected by extreme climatic conditions, they have no medical insurance, low educational attainment and their age is above 60. The chances of redeployment may thus be limited in order to improve their livelihoods. Across the other villages, it was found that the individuals were found to be moderately vulnerable, 19 are from QS, 2 from PAP and 7 from RDG. In QS, 10 women were found to be moderately vulnerable, 1 woman in PAP and 3 in RDG.

#### Social Capital Vulnerability

It is found that overall 10 men and 3 women are highly vulnerable as far as social capital is concerned in all the four villages, while the greatest vulnerability figure occurs in the region of PAP, where 8 men and 2 women were found to be highly vulnerable and 2 men and 1 woman in RDG. This type of vulnerability is based on the fact that the respondents are not in good terms with their neighbours, they are neither a member of any local association and they are not locally very active or participative in any event. These traits reflect their inability to be socially active and to either seek assistance in the presence of natural calamities or to assist others.

#### Physical Capital Vulnerability

With respect to Physical Capital vulnerability, it is observed that there are actually 8 men and 9 women who are highly exposed. Among these, the highest number of vulnerable people are found in PAP, where there are 7 men and 5 women households found to be highly vulnerable. The rating in this context is based on the fact that the respondents do not own their house, their house is located close to the sea, they do not

own any other plot of land elsewhere and have no contingency in terms of back up for gas, water and electricity in case of extreme climatic events. In the other villages, 1 man and 3 women are vulnerable in QS, 1 man in CN and 1 man and 1 woman in RDG.

#### Financial Capital Vulnerability

When addressing the issue of Financial Vulnerability, it is found that 1 man and 1 woman were found to be highly vulnerable across the four villages and this emanated from the village of PAP. In other villages, this extreme situation was not found despite the fact that many respondents were found to have an income below Rs 5,000, and who could thus be considered as economically-disadvantaged. This vulnerability was based on the fact that the respondents in addition to an income below Rs 5,000, are indebted, have not inherited any asset or property, have their business affected by climate change and expect their income to even drop further in future. Low level of financial vulnerability was observed among 6 individuals interviewed in QS and 10 individuals interviewed in RDG.

## **5.2 Sustainable Livelihoods, Resilience and Climate Change**

Our methodology provides several levels of vulnerability related to climate change. These levels vary according to the degree of impactedness of extreme weather events on communities and people. People living, for instance, in buildings whose structures are fragile and who also live very close (within high water mark) to the sea are those who would be immediately affected. Hence vulnerability has been classified into three types, namely, highly vulnerable, moderately vulnerable and less vulnerable. We provide further information to identify such categories among the various people that have been interviewed so far.

Given the demographic, physical and human capital aspects of these respondents, such people are bound to be affected whenever there will be extreme weather phenomena, such as tropical cyclones, flooding and wave surges. In both summer and winter they may be exposed to the high tidal waves that sweep the coast of Mauritius during episodes of strong anti-cyclones and cyclones. Moreover, these people will not

be able to move out of the areas where they are actually located to live elsewhere. They have very limited wealth and low income to allow them to shift from one place to another. Besides being geographically immobile, the people would find it hard to sustain their livelihoods in the long term. This is indicated by the heavy dependence on nature for a living either as a fisher, farmer or small planter. The low income does not allow such people to save enough and to invest in building a house. Their financial constraints would not as well make them eligible for a housing loan. While income may fall, they have yet to support a family which has relatively a large number of dependents. In addition to houses being in wood or iron, some of the households are not even owners. As tenants, they may not be allowed to modify the structure of the house nor consolidate it whenever there is the threat of some natural catastrophe potentially affecting Mauritius.

By virtue of their demographic and other human characteristics, squatters have become in the forefront of dangers related to extreme weather events. Squatters located in the regions of CN, PAP and RDG who live simply next to the sea, are bound to be affected more dangerously whenever there are storms that move from North to South across the west coast of the island. This part of the island ultimately falls into that segment of the cyclone considered as most violent. Associated with these extreme cyclonic conditions are the huge tidal waves that sweep over any man-made construction located too close to the shore. While by regulations, construction of buildings (commercial and residential) should be at least 30 metres from the high water mark, there are many houses and bungalows including hotels that have been constructed decades ago and located along the shore.

#### *5.2.1 Sustainable Livelihoods Vulnerability*

Based on the five forms of capital defined above, there are 34 individuals out of 422 interviewed are bound to have unsustainable livelihoods in the near future. This is rated based on the overall sustainability index. The latter is obtained by summing up the vulnerability level from each form of capital. The overall index is based on a score of 27 (Human Capital vulnerability score = 7, Social Capital vulnerability score is 3, Physical Capital Vulnerability score =5, Financial Capital Vulnerability score =7 and Natural Capital Vulnerability score = 5). Without any assistance, it would be really

difficult for these 34 individuals to derive a decent income and to sustain their livelihoods. They will continuously be affected by climate change shocks.

### *5.2.2 Loss of Life Vulnerability*

People who are at the greatest risk of being badly injured and losing their lives during extreme weather such as passage of tropical cyclone, flooding and wave surges are those who live in houses that could be easily destroyed or swept away. Our methodology allows us to track these people through Physical Capital Vulnerability and there are 17 individuals who are concerned, 8 men and 9 women and of which 7 men and 5 women have been identified in PAP, 1 man in CN, 1m and 3 women in QS and 1 woman in RDG. Beyond being vulnerable to be injured, this measure also relates to the danger of someone losing her/his life.

### *5.2.3 Loss of Output and Income Vulnerability*

This is linked to those people, especially small scale planters and farmers, whose businesses are climate-dependent. Extreme weather events may thus reduce their output and result in loss of income for several days. Our framework reveals that there are 14 respondents who would be medium to high rate vulnerable to such events. This figure relates to 1 man from PAP as highly vulnerable, 2 men and 3 women moderately vulnerable in CN, 3 men and 2 women moderately vulnerable in QS and 2 men and 1 woman again moderately vulnerable in RDG.



## **CHAPTER 6:**

### **POLICY IMPLICATIONS**

#### **6.1 Introductory Note**

This chapter addresses issues that have been raised in the previous two chapters by providing alternative policy recommendations conditional on the findings. These are to a large extent meant to reflect institutional transformations that need to take place, as well as rethinking strategies to involve coastal communities and relevant stakeholders to take a serious look at climate change effects on people. At least a preparedness plan could be set up that would gradually put in place the relevant mechanism encompassing greater adaptation and mitigation strategies. Rather than a management by crisis method, the mechanism to be established must be systematic ensuring more commitments of the central and local governments to ensure an equitable and effective intervention.

#### **6.2 Climate Change Insurance Cover for Output and Income Losses**

Our findings have revealed that a great majority of the people who use the natural capital or the physical environment to earn a living have to suffer huge income losses during extreme weather situations. Moreover, there is no systematic compensation mechanism that exists to assist the affected parties financially. Any form of monetary assistance is done on a case to case basis and without a proper template that uses a holistic approach. It is known that registered fishers who do obtain bad weather allowance, but there is no such scheme to support the small farmers and planters, who are equally vulnerable to severely bad weather. It would thus be appropriate if an insurance scheme be set up with two to three tiers, whereby first tier is contributed by the state and the second and ultimate tiers be contributed by the planter or farmer himself. Such scheme would benefit these people in case of natural disasters. They need to have a licence from the DC to benefit from such scheme either as a small scale farmer or planter. Fishers could also have a scheme that would provide a better coverage over and above the 'Bad Weather Allowance'. Thus, such a scheme may not only compensate against bad weather but other climatic phenomenon too that could manifest itself in the form of unexpected currents and sediments affecting fish catch.

### **6.3 Medicare for Climate-Change Related Illnesses**

While health centres and public hospitals are already working hard to keep the population healthy, there is little which has actually been integrated within the current services provided to address impacts of extreme weather patterns on the health of people especially in coastal regions. This could also include vector-borne and water-borne diseases currently found in the tropics, and Mauritius is of no exception. Climate change will be associated with the rising of such diseases commonly found in Mauritius, though on occasional basis, could be harmful to specific communities. The Chikungunya episodes of 2004/05 could be used as a good lesson to indicate the lack of preparedness of Mauritian authorities to address such an event. Malaria and Dengue could be other illnesses related to evolving climatic patterns. They may become more regular especially if authorities do not consolidate their efforts enough to circumvent these problems. Special care could as well be provided to those people who suffer from illnesses that have to do with extreme weather such as heat waves, cold winters and high humidity. Regional health centres might have to provide extension of their services such a mobile ambulance facilities for those patients who need advanced care and suffer from physical disabilities or due to ageing. The growing ageing population would definitely lead to a greater demand for such intervention during extreme weather.

### **6.4 Local Government Support**

With the expected increase in extreme weather events, there is no doubt that the local government would have a very crucial role to play due to its proximity in addressing regional problems. Village Councils (VCs) and District Councils (DCs) would thus have to include in their scheme of functions, activities that would encompass a preparedness plan in anticipation of more frequent climatic extreme weather over the island. At different levels VCs and DCs would have to intervene and they would require additional financial assistance as well as relevant expert support in providing extension services to people in general, planters, farmers and fishers given the era of climate change. Their scope of operation would have to entail the following:

#### *6.4.1 Financial Support to People at Risks*

Here we argue that local government should be able to provide financial assistance to families who could be immediately impacted by extreme weather events since their houses are at risks, due to their location, structure and size. Funds could be earmarked by the central government to provide such support. This obviously should use a means tested approach and the most vulnerable ones could benefit from the scheme.

#### *6.4.2 Financial Aid to Small Farmers, Planters and Fishers*

These three categories have been found to depend much on nature or the natural capital. The government could again try to find out through certain established schemes how to compensate these people whenever they suffer from output and income losses. An earmarked fund should exist with constant monitoring and accountability to ensure that the affected parties are well compensated and not discouraged to give up their current activities. Moreover, this scheme should address all forms of weather extremes. This scheme should be in line with the climate change insurance cover already discussed above and managed by the DC or privatised.

#### *6.4.3 Working with NGOs and Social Networking*

Given that many people interviewed have indicated their mobility could be drastically reduced during and after extreme weather events because of fallen trees, hanging electric lines and damaged poles, amongst others; the local government, in particular, the VCs, could already work out a preparedness plan with the various local associations to come to the rescue of people after extreme weather events have occurred or even before in order to minimise loss of lives, injuries or casualties. Such networking could also assist in removing obstacles and debris following floods and cyclones in assisting other emergency services. All in all, sensitization campaigns could be organised to address climate change issues especially consequences of extreme weather on the health, economic and social activities of people. Activities in conjunction with local associations and NGOs could be thus organised to that effect.

#### *6.4.4 Proper Water Drainage and Maintenance*

It has been reported in FGDs that there are often problems related to maintenance of local services in terms of cleaning of drains across the main roads and that in certain villages public infrastructure might be dated. If these drains are not cleaned regularly and, in particular, during the summer season, there is bound to be proliferation of water-borne diseases as well as greater dangers for flooding. The latter may be particularly a problem with houses that are located very close to roads and in shallow areas. In addition to the regular cleaning of public drains, it must be ensured that people in general do not tamper with such drains in trying to connect their own private drain such as waste water pipes or used water to the public ones. All in all, there should be more intervention to identify defects in both public and private infrastructures in flood-prone areas. The Ministry of Environment and Sustainable Development is already engaged to address such issues especially where bridges and river banks were found to be major sources of flooding during heavy rainfall. There are still some gaps left especially with respect to the levelling of roads and water evacuation in newly established residential zones. More advice could be provided by the local government to building promoters and people in general to reduce flood risks whenever they are constructing their buildings, whether commercial or residential.

What could be further proposed is a flooding map that could identify defects in both public and private built-up areas. Such sighting is important to reduce the long run dangers associated with flooding in specific areas and the economic as well as human losses arising from it.

#### **6.5 Central Government Commitments**

While the local government could play a crucial role in addressing climate change issues due to their proximity, there is much to be done by the central government at the national level to seek the necessary finance for local government to better address climate change issues as well as consolidation of a national plan for natural catastrophes. These would require the mobilisation of services and units that fall under its control and that obviously would require a lot of funding and scoping of services. Here again, it is known that there exist national committees that intervene

whenever there are storms and floods. But what is required is a think tank that would develop a systematic plan for better adaptation and mitigation.

#### *6.5.1 Addressing Water Shortages and Deficient Rainfall*

During episodes of droughts, the villages and coastal communities are badly affected. This is particularly because of the few reservoirs that distribute water to several stakeholders including hotels and cultivated areas as well. It would be an opportunity for the government to explore through its Maurice Ile Durable project how firms and households could be encouraged to harvest rainwater through cost-effective methods. It is known that there are still few households that do have water storage facilities such as their own water-tanks and water-reserves; however, this may not be enough. There are other avenues or channels that could be explored to capture rain water for both domestic purposes and irrigation by planters and/or livestock maintenance by farmers. These new methods are to store rain water rather than tap water for both these domestic and commercial purposes and would greatly help out during hard times such as deficient rainfall seasons and water cuts from the Central Water Authority. This would require a major feasibility study to scope the nature and extent of this type of project to reduce the effects of droughts on people and the economy. The central government may start this project with communities that are most prone to droughts or where annual rainfall is severely deficient such as CN and PAP.

#### *6.5.2 Squatting and Relocation*

It has been observed that squatters constitute the most vulnerable communities. The fact that these communities squat state-owned lands and that too which are located almost along the shore as in CN and RDG makes them highly vulnerable to sea-level rises, storm surges and flooding. In addition to these communities, there are as well people who have since ages settled in places very close to the beach, at QS and PAP. Some of these people have as well been found to be highly exposed to extreme weather events. Their very high vulnerability should prompt local authorities to establish, through a preparedness plan, the possibility of relocating such people to areas which are much safer. Obviously, the social and economic costs might be very high in relocating such people. Relocating could be the only solution to avoid loss of life in this context. However, the preparedness plan should also address the issue of

immediately preventing people from squatting beaches or areas along the coast thereby increasing the vulnerability of communities. In QS the government is already addressing the issue of landslides. A relocation plan is already in place but more similar plans and projects should be considered through a special budget to locate people gradually to much safer places.

### *6.5.3 Support to Adapting to New Farming and Agricultural Methods*

It would be equally important for the government to establish action plans through the Ministry of Agriculture to help farming and planting communities with respect to new techniques that would better adapt to climate change. It has been found out through the interviews and focus groups that most of the planters and farmers, though they produce on a relatively small scale, do contribute enormously to their local economy and community and even beyond. They provide vegetables, meat and livestock production to the local community. While this is also an important source of income for them, it also helps to create employment opportunities for other members of the family or of the community. One major aspect that has been observed is that most of these people practising agriculture and farming do not have formal training at least to address the problems related to climate change. To reduce their financial dependence on the government and eventually tax payers, these people could be provided some formal training while apprising them at the same time of new adaptation techniques as well as mitigation plans in order to minimise income, output and employment losses. A whole programme could be set up in this direction to educate the concerned communities in a very pragmatic manner helping them to develop resilience. Water storage facilities as well as new irrigation methods could be provided to deal with rainfall deficiency as well as excessive rains running through the fields. On the other hand, they might be taught how to conserve the soil and its fertility in order to enhance agricultural as well as farming productivity in the long run. AREU, for instance, could provide the necessary inputs to develop capacity within the concerned communities and it should be a joint programme of support involving the Ministry of Environment and Sustainable Development as well. Farmers could also benefit from the training programme in terms of how to enhance their livestock and to combat climate-change related diseases affecting their businesses. In the region of Quatre Soeurs, the problems related to flooded farms especially, among onion growers, must

be addressed effectively. It could be through specific relocated agricultural sites or different techniques such as efficient canalisation of fields to reduce salt water intrusion.

#### *6.5.4 High Prices and Food Shortages*

It has been commonly observed that extreme weather events have got serious implications for prices of agricultural goods and livestock production. This matter needs the attention of policy makers especially when the latter have to map the long run implications of climate change. The passage of a severe storm, several days of torrential rain or even significant deficiency in rainfall may lead to acute food shortages. Besides, the deaths of several animals being reared for livestock production, there may be an acute deficiency to meet the demand of consumers, particularly, with respect to vegetables. Their extremely volatile prices especially after the extreme events and their perishability make it difficult for any one to afford these products. Financially-constrained households are the most affected ones. Hence, acute food shortages coupled with high prices should be a concern of the authorities. There could be concrete plan of action to increase and protect agricultural farms, empower farmers and planters to encourage greater production and to develop crop-resistant substitutes. The ever increasing demand for vegetables, fruits and meat from both the household and tourism sector, on the one hand, and the increasing climate change extremes, on the other hand, would undoubtedly create more acute shortages of food items, food insecurity and much higher inflation. This recommendation is specifically to address climate change by the concerned authorities given that the affected parties do not actually have concrete business plans and the required knowledge to adapt to new crop specifics or how to combat climate-change related pests affecting plants and animals.

#### *6.5.5 Improving the Marine and Coastal Environment*

Given that artisanal fishing methods characterise the fisheries sector in Mauritius. The impact of climate change would be felt more significantly in terms of magnitude and frequency on marine resources given the topography of the island. On-shore lagoons would be seriously impacted by more sediments carried away into the lagoons through rivers during episodes of floods or tropical cyclones closing over Mauritius.

Such sedimentation would have a direct impact on fish production and catch. In PAP, CN and QS these are frequent features that have been revealed during the survey. To reduce dependence on on-shore lagoons, fishers could be empowered to fish more off-shore with more sophisticated techniques of operation. They would hence need financial support as well as training for this purpose. Otherwise, fishers could be encouraged to enter more in fish farming through aquaculture and fresh water fish farms whereby they could sustain their livelihoods and reduce the damages that the weather could do to their agri-businesses ultimately. A more fundamental role should as well be played by research institutions to replenish our lagoons over the long run in terms of species and quantity. In unprotected coastal areas, mangroves should be replanted in order to reduce beach erosion and as well to play an ecological balance in reducing the impact of storms on the coastal line of the island.

#### *6.5.6 Setting Up of a Climate Change Observatory*

There should be an independent body that would be assigned the tasks of keeping a systematic record of all the damages, social, economic, environmental and ecological, amongst others, which could arise in a year from extreme weather events. This would make it easier to keep track of in kind and monetary losses occurring thereby assisting in the setting up of adaptation and mitigation strategies and plans. The Observatory would also indicate how different stakeholders, the civil society, private companies, governmental organisations and the physical environment, have been impacted and adversely affected by any abnormal and damaging weather system during a given year. Based on its annual report, compensation mechanism could be developed with the support of the government or the climate change insurance scheme discussed above. However, it would need to have the necessary expertise, preferably, with multi-disciplinary profile, to be able to assess, evaluate and make recommendations to the government. In short, the Observatory would bridge the gap between economy and society and climate change.



## **CHAPTER 7:**

### **CONCLUSION**

This research has investigated into the vulnerability of coastal communities in the island of Mauritius and has particularly studied four coastal villages, namely, Case Noyale, Pointe aux Piments, Rivière des Gallets and Quatre Soeurs. All in all, 422 interviews were undertaken and these were backed by Focus Group Discussions at an early stage prior to actual field work.

The Sustainable Livelihoods methodology was adopted to evaluate the extent to which Mauritians located in these villages might be exposed to extreme weather conditions, mostly, increasing tropical cyclones (intensity and frequency), floods and droughts and bearing their consequences. However, the analysis does not exclude other related phenomena such as sea-level rise, increases in sea temperature, wave surges especially during cyclones. Our methodology also allowed us to analyse the extent to which coastal communities are prepared to face such extreme weather events as and when they are expected to occur. The study also encompasses, fishers, farmers and planters, who are often at the mercy of natural catastrophes.

Findings of this research reveal, amongst others, that the poor communities are the ones at risk. Three levels of vulnerability were ascertained and analysed, namely, Sustainable Livelihoods Vulnerability (SLV), Loss of Life Vulnerability (LLV) and Loss of Output and Income Vulnerability (LOIV). SLV is also a measurement of the vulnerability of the households over the long term and helps to indicate the degree of resilience that could be built up by them. In this category, it was found that 34 individuals scored the maximum points of 27 used in the computation of this form of vulnerability. Out of the 34, 13 were female respondents. With respect to LLV, it was found that there are 17 people who are at immediate risks of losing their lives as they are highly exposed to the danger of storm surges, flooding and wave surges. Out of this figure 9 were found to be women. Lastly, LOIV relates to small scale planting and farming communities whereby it was found that 14 respondents are vulnerable and of which 6 are women. These are people whose income depend to large extent on nature and weather conditions.

The income of those people who are vulnerable in either of the three categories are found to be households deriving a monthly income of Rs 5,000 or less, they live very close to the shore, they do not own their house and land, the house is made up of iron sheets and wood while their income is dependent on the caprices of nature.

Without the help of the government, these vulnerable ones would not be able to come out of their difficulties. They would continue to be exposed across generations and would remain at the mercy of natural hazards. The government must adopt a preparedness plan with strong delegation of commitments to District and Village Councils for a holistic and long term approach to build up adaptation and mitigation strategies as soon as possible. Local associations and NGOs may as well play crucial roles in the consolidation of all efforts in the struggle against natural catastrophes as and when they would occur. This research also emphasises the need for a climate change observatory to bridge the gap between economy and society and atmospheric disturbances.

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