

UN-HABITAT

Vulnerability Assessment



**Interim Report on Vulnerability to Climate Change in Sihanoukville
Municipality**

Research, Analysis, Findings and Recommendations

January 2012

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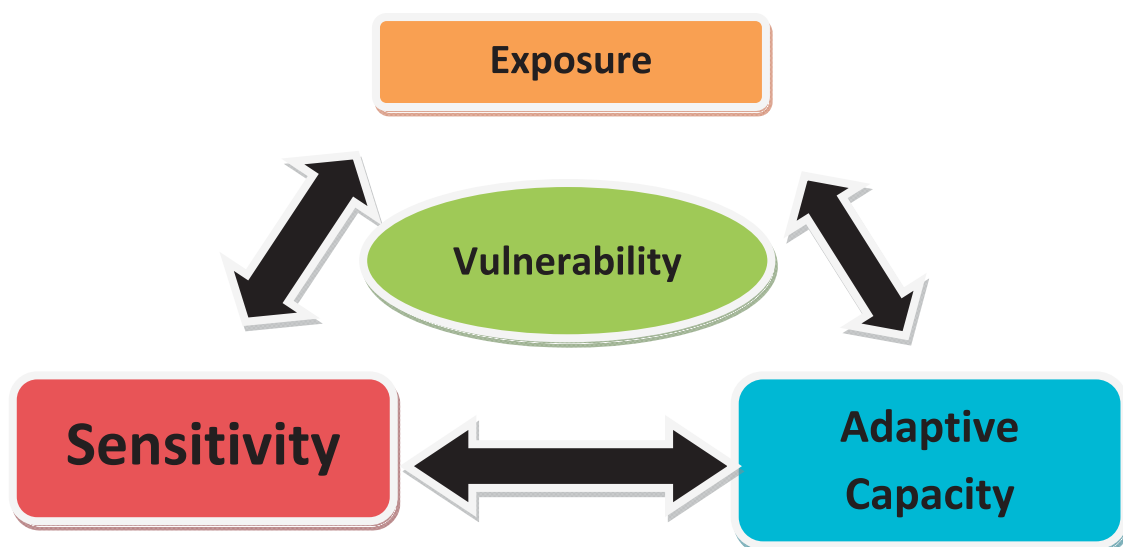
Overview

The UN-HABITAT vulnerability assessment in Sihanoukville was designed to measure exposure, sensitivity and adaptive capacity (collectively understood as vulnerability) to climate change in the Municipal area of Sihanoukville. A variety of methods would be used in order to establish this; firstly, a substantial policy and document review. Secondly, extensive and in-depth interviews and focus groups held with a variety of stakeholders at national and local levels. Finally, in-depth vulnerability assessment focus groups were conducted with several communities. The assessment also considered stakeholders such as the private sector and non-governmental organisations, and issues such as climate science, economic and urban planning issues, as well as the link between climate change and other environmental issues in the city, such as waste management.

Cambodia has a sensitive environment, which has suffered from exploitation and management issues. According to vulnerability mapping carried out by the Economy and Environment Program for Southeast Asia, Cambodia along with the Philippines is, the most vulnerable country to climate change in Southeast Asia¹. This is due to its exposure to floods and droughts, sensitivity through reliance on agriculture and lack of adaptive capacity through a combination of low incomes and a lack of skills and infrastructure. Relatively little assessment has focused on urban areas in Cambodia, partially due to the largely agrarian nature of the workforce.

Assessment Framework

The assessment framework considers vulnerability of being made up of Exposure+Sensitivity-Adaptive Capacity.



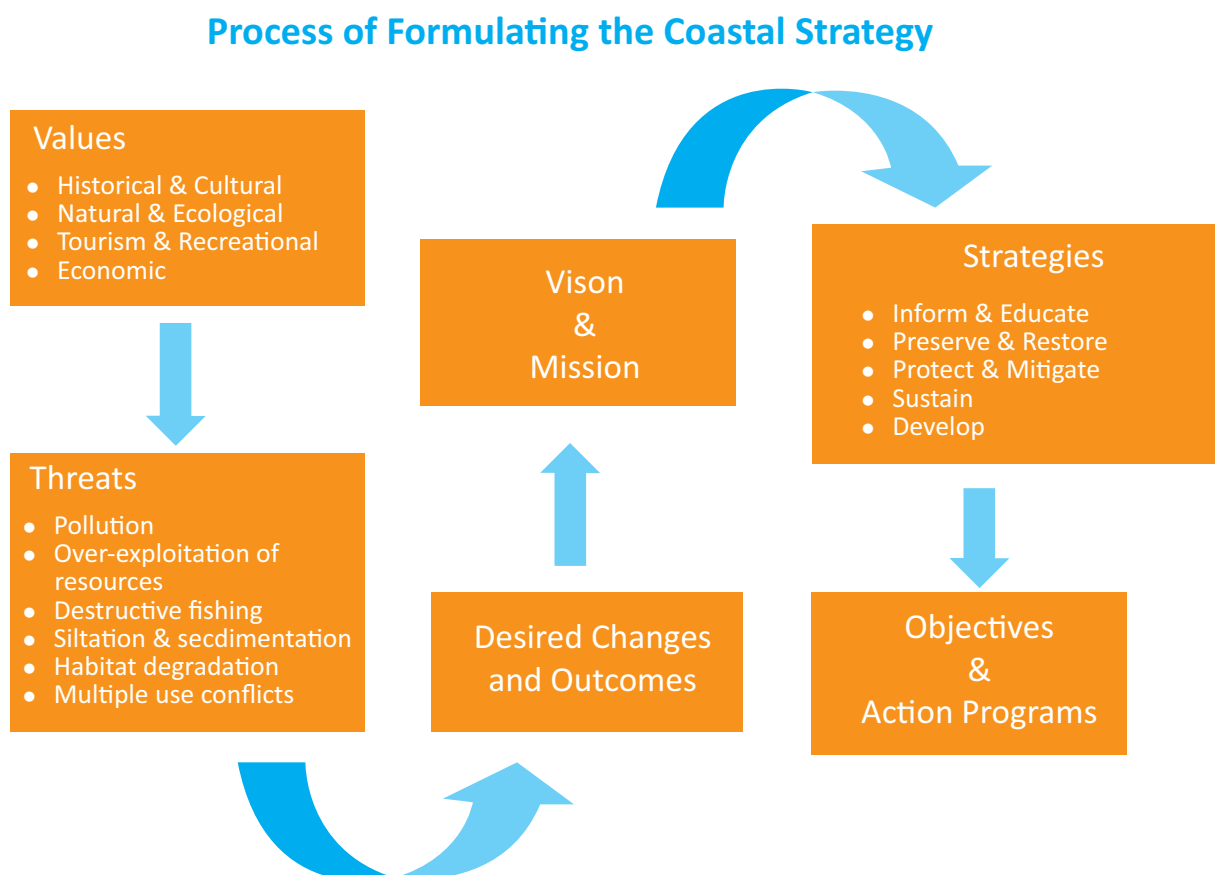
¹ Yusuf and Fancisco, 2009, Hotspots – Vulnerability Mapping in Southeast Asia

Policy Context

Climate change is addressed in numerous policies which have been adapted by the Royal Government of Cambodia. Cambodia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and acceded to the Kyoto protocol in 2002. Also in 2002, the Royal Government of Cambodia, through the Ministry of Environment published the Initial National Communication to the United Nations Framework Convention on Climate Change. This was the first document which contained a detailed, nationwide vulnerability and adaptation assessment, the findings of which are still influential in programming. The National Adaptation Programme of Action, detailed in section 4 followed on from this and was published in 2006. The National Adaptation Programme of Action recommends various project actions, though only now are these beginning to take place and their implementation remains patchy.

The Rectangular Strategy for Growth, the official framework for economic and social development, as outlined in the National Strategic Development Plan, while not specifically tackling climate change mitigation or adaptation, does cover several issues on which climate change can reasonably be expected to have an impact. A national strategic action plan for climate change is currently under preparation by the Ministry of Environment

Figure 1 - Coastal Management Strategy²



² Sihanoukville Coastal Strategy, 2002, p.24

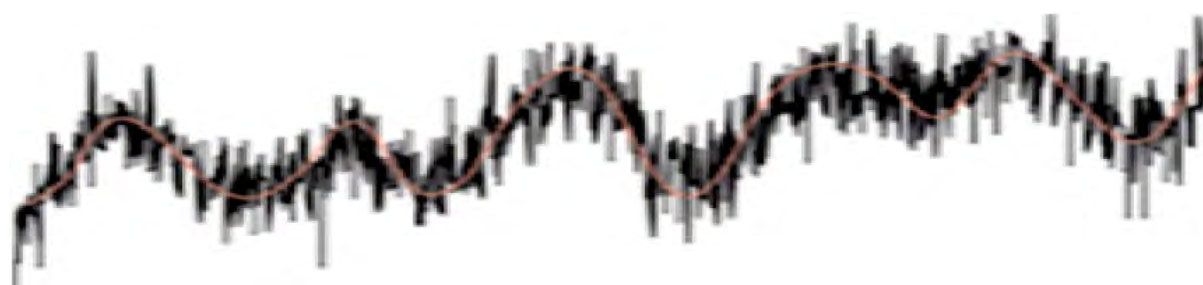
The above diagram shows the process flow of the coastal strategy. While some of the identified threats relate to the scope of the this report, the planning process for the strategy took place in 2001, and, given the rapid development which has taken place since then (partially according to the strategy) its relevance is only limited now, hence has not been widely considered here.

The Provincial Environmental Management Plan, covering 2011-2015, has also been prepared. This document remains at draft stage and has not been finalised, approved or incorporated yet, and at present the Province is deciding whether to re-align this to become an overarching ‘sustainable development plan’. The plan does not make extensive provisions for climate change at present.

Weather and Climate

Distinguishing weather from climate is key to the assessment, because making such a distinction is important to awareness raising with local stakeholders, and generating useful data from communities. “Weather” is the day-to-day state of the atmosphere in terms of temperature, moisture content and air movements³. Weather, therefore, is something observable, which can change over the course of a few hours, days or weeks.

Figure 2 Fluctuations in weather patterns in a given period⁴



Climate, however, is a scientific concept, measured using statistics over a long period of time; at least 10 years, but more often 30 years. Measuring the climate requires aggregation of weather data over such a period. Climate therefore, is not ‘conceivable’ in the minds of individuals, whereas weather is. This creates a challenge in climate research, because gaining perceptions of something which is inconceivable, (the climate and if it has changed) is difficult, particularly when it is readily confused with the weather (which is conceivable).

Figure 3 Fluctuations in climate patterns over the same period⁵

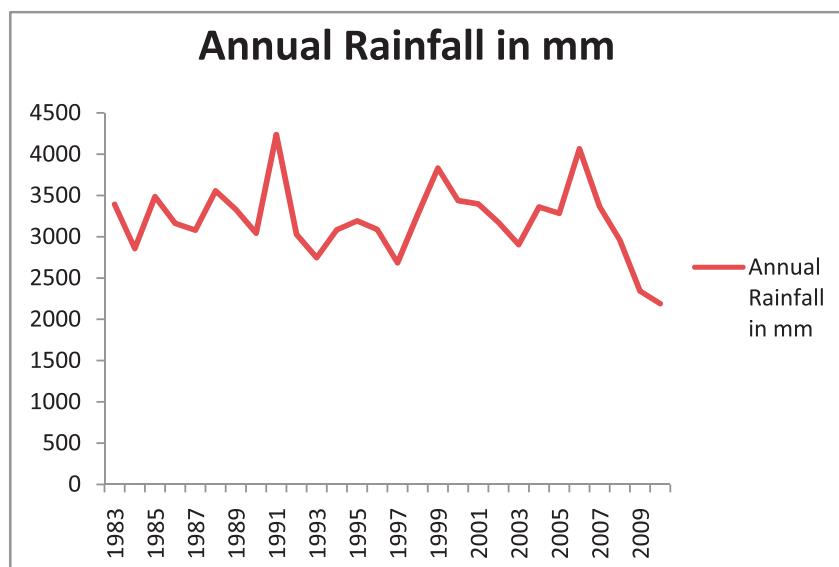


³ Climate Change Information for Effective Adaptation; A Practitioner’s Manual (2010), GIZ, p. 12

⁴ GIZ (2009) Climate Change Information for Effective Adaptation; A practitioner’s Manual, p.13

⁵ ibid

Figure 4 - Annual Rainfall

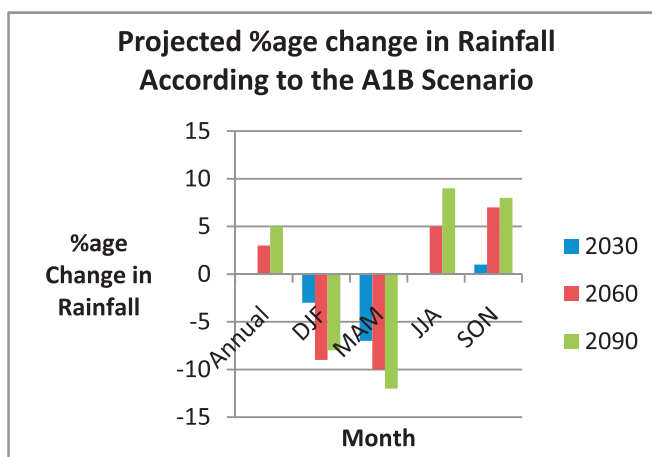


Due to its location on the coast, its proximity to the Cardamom Mountains and the influence of the inter-tropical convergence zone, Sihanoukville has significantly higher rainfall than many other parts of Cambodia. According to the UN Food and Agriculture Organisation, average annual rainfall for Cambodia is estimated to be around 1,400mm⁶. In Sihanoukville

average annual rainfall in the period 1983-2011 was 3198mm⁷, more than double the national average. The outcome of this is that Sihanoukville experiences heavier rainfall events than much of the rest of Cambodia. These heavier rainfall events create additional and unique pressures on the city infrastructure and population, particularly through flooding, drainage issues and waste water management.

Figure 5 - Project percentage change in rainfall

While it is difficult to observe a distinct trend in local rainfall patterns, it is clear that 2009 and 2010 are the 1st and 2nd driest years since recording began. National rainfall data since 1960 tallies with local data shown in figure 4 in that there does not appear to be any consistent increase or decrease since 1960. Likewise, the amount of rainfall which occurs in 'heavy' events, shows no consistent increase or decrease. In 2011 there was significantly more rainfall.



Future projections of rainfall are again quite inconsistent, but generally show that there will be higher annual rainfall overall. This rainfall will be spread unevenly throughout the year, with increased rainfall throughout the rainy season and a reduction in the dry season. The proportion of rainfall which will occur in 'heavy' events is projected to increase by up to 15%, which could be an indicator that storm intensity will increase.

⁶ <http://www.fao.org/nr/water/aquastat/countries/cambodia/index.stm> accessed 12/4/2011

⁷ Provincial Department of Water Resources and Meteorology statistics

Sea-level Rise

Localised measurement of observed sea level rise is not in existence. Local mean seal level is defined as the height of the sea relative to a fixed point of local land averaged out over a given period of time, normally a month or a year. There are several causes of sea-level rise, however, it is thought that thermal expansion, the increase in volume of water as it gets warmer, is considered to be the leading cause of sea-level rise at present⁸. The melting of glaciers and polar ice sheets may become more significant in the future, dependent on greenhouse gas emissions and future temperature increases, particularly at the North and South Pole. While the science behind glacial melt and its possible future effects are not fully understood, it has been predicted that this alone could contribute to sea-level rise of 1metre per century⁹.

The local impact of between 1 and 2 metres of sea-level rise could be severe, particularly for the low-lying Turnup Rolok community, which is home to many of Sihanoukville's urban poor. Tidal variation can be up to 0.7metres per day.

Storms

Storm frequency and intensity, which couples strong wind and high waves, is predicted to increase under all climate change models and emissions scenarios. Provincial level data shows that of the four coastal provinces Preah Sihanouk Province is the most exposed to strong winds in the future¹⁰. Occurances of strong wind, defined as being higher than 40kph, are predicted to become more frequent in the next 30 years. Under these conditions, wave heights of up to 6 metres are possible, while winds of that strength may damage homes with thatched or fibro roofs.

Temperature Change

Nationally, the mean average annual temperature has increased by 0.18c since 1960. The change is more pronounced in the dry season (November to May) with an average change of up to 0.23c, with a slower change in the wet season of between 0.13-0.16c. The frequency of 'hot' days and nights, defined as where the temperature is 10% or more above the average for that time of year, has increased significantly since 1960. There are now 8 hot days and 7.4 hot nights per month during the dry season. The number of 'cold' days, defined as where the temperature is 10% or more below the average for that month, and nights has decreased sharply¹¹.

⁸ UN-HABITAT, (2011) Global Report on Human Settlements, p.66

⁹ ibid

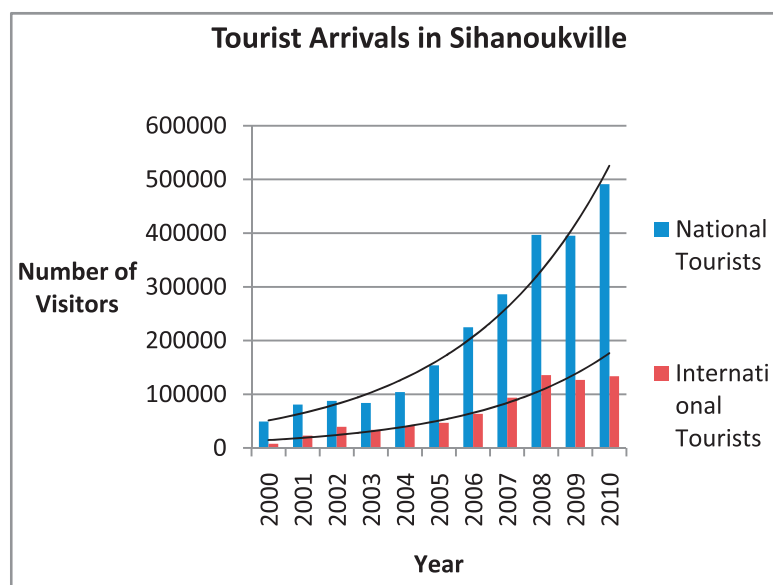
¹⁰ Ministry of Environment, Second National Vulnerability and Adaptation Assessment Report

¹¹ Mc Sweeney, C, New, M, and Lizcano, G (2009) UNDP Cambodia Country Climate Change Profile

Sensitivity in Key Industries, Livelihoods and Ecosystems

Tourism

Figure 6 - Tourist Arrivals in Sihanoukville



Tourism is an important industry for Sihanoukville, with up to 60% of the population deriving some or all of their income from it. Tourism has become an important sector in the Cambodian economy, and since 1999 there has been a rapid increase in the number of foreign and domestic tourists visiting the country.

The sensitivity of tourism to climate change is mixed, and is unique from other industries.

Sea-level rise presents a serious

threat to the existence of the industry because the beaches would erode and decline in size. The potential to create artificial beaches remains unknown given the lack of precedent for this, the cost and likely engineering complexity. Sea-level rise would also jeopardise tourism to the islands for the same reason. The infrastructure required to protect the beaches against sea-level rise is most likely prohibitively expensive.

Unlike other industries, tourism has the potential to benefit from the projected seasonal shift¹². A longer, dryer dry season would mean an extension of the high season for Sihanoukville. However, capitalising on this is not easy. Rainfall data shows, there has been little observable shift so far – perhaps the only observable change is that rainfall is declining in the months of May and June. This would echo the predictions being made about seasonal shift in Cambodia¹³ and therefore, ways could be sought of attracting tourists particularly during those months. Job creation through tourism should represent a key strategy towards adaptation, and the government could seek ways to ensure that the beneficiaries of this area those who are most vulnerable in other areas, especially seasonal shift.

¹² National Adaptation Programme of Action (2006)

¹³ *ibid*

Fisheries

According to the District Data Book, in 2008, 10% of families in Sihanoukville derived their primary income from catching fish¹⁴. In livelihood terms, fisheries are sensitive through the economic damage which can occur to boats and other fishing equipment as a result of storms and in human terms, loss of life which occurs, also as a result of storms. According to both the Provincial Fisheries Administration and the communities themselves, it is common for fishermen to spend up to a week at a time at sea, significant distances from the shore in such boats^{15,16}. Many residents highlighted the damage which has been done to such fishing equipment, and that, in each of the previous two years, boats have sunk at sea, causing loss of life.

The assessment team was not able to estimate the economic cost of loss of fishing boats. Many of the fishing boat piers in Sihanoukville are privately run, in some cases by Thai operators, which make gathering official data on their operations difficult. The present lack of availability of accurate weather forecasting to fishermen compounds their sensitivity, by forcing them to fish at times or in areas which may not be safe for them to do so. This, combined with increasingly unpredictable storms and higher wave heights, which is a possible future scenario, heightens the sensitivity of marine fisheries.

Marine Ecosystems

Sihanoukville's marine eco-systems are highly sensitive to human activity, including the impacts of climate change. Of great significance is the presence of coral reef. Coral supports many other forms of aquatic life which in turn is an essential source of livelihood and commercial activity. The Ministry of Environment assessment found the condition of Cambodia's coral reefs to be generally poor¹⁷. There are large areas of coral reef off the coast of Sihanoukville, much of which is close to the shoreline and in areas commonly used by local fishermen. Coral reef also provides protection to the coastal zone from the impacts of sea level rise, including sedimentation, and has potential to attract increased tourism through diving and snorkelling activities.

Figure 7 - The Road for Sihanoukville to Stung Hav



The main climate change threat to coral is 'bleaching'; a recent report showed levels of bleaching were found to be low. Only around 7% of the coral population surveyed was found to be bleached¹⁸. Because the negative effects of coral bleaching are difficult to reverse once they take effect, there is now an opportunity to prevent damage to coral and prevent future losses. The effect of coral bleaching can also be classed as highly sensitive because it has wide ranging

¹⁵ Mr. Doung Samath, Director, Fisheries Administration, Personal Communication

¹⁶ Tumnap Rolok Community consultation – 25/11/2011

¹⁷ Ministry of Environment, Second National Vulnerability and Adaptation Assessment Report

¹⁸ Serendipity Beach Marine Environmental Assessment, Sihanoukville, 2011, Marine Conservation Cambodia, p.19

impacts on the livelihoods of local people. Its impact on fish population will, in turn, adversely affect quality and diversity of fish available to local people, and as such practice their livelihoods, while bleached and damaged coral with damage the growing number of snorkellers and scuba divers, who represent an important section of the tourist industry.

Sensitivity in Infrastructure and Human Settlements¹⁹

Infrastructure

Unsealed roads are more vulnerable to rainstorms and flooding. To examine this further, the assessment team met with community members in Sangkat 4, close to Psar Leu – the city’s main market – who described that their homes and businesses had been negatively impacted by erosion, garbage and general detritus as a result of rainstorms on unsealed roads. In addition, drainage is an issue on many roads, which can be expected to become more serious in the future, should projected changes in rainfall occur. Many people who the assessment team spoke to recommended that drainage be improved in order to prevent this problem occurring more frequently under projected increases in rainfall.

The road to Stung Hav, pictured in figure 7, an area of future industrial development (and the site of a new port terminal), is also under threat from sea-level rise. 1 metre of sea-level rise will put sections of the road under water. The road has also been identified by the Japanese International Cooperation Agency as being inadequate, and although consideration has been given to up-grading the road, no firm plans exist at present to upgrade it²⁰.

Housing

In 2008, 78% of houses in Sihanoukville had a Zinc/Fibro roof, while a further 3% had a thatched roof²¹. According to the ranking determined in the Ministry of Environment, thatched, fibro and zinc roofs, are the three most vulnerable types of material to storms.

Informal settlements such as Tumnup Rolok are indicative of higher sensitivity because housing structures are less likely to be permanent or well constructed and therefore houses in this area are especially vulnerable when on the coast. Because of this, we can deduce that informal settlements in Sihanoukville are generally more sensitive to climate impacts due to the nature of housing which exists within them.

As the final draft of the report was being prepared, in July 2011, a storm damaged 27 houses in Tumnup Rolok, destroying beyond repair 7 houses and severely injuring 1 person. This is in addition to a storm in May in which 4 houses were destroyed²². Loss of life has been reported in previous years in the area, and given the lack of forecasting and information, the risk to people in informal settlements becomes

¹⁹ Picture in fig 7 ©UN-HABITAT/Liam Fee

²⁰ JICA Masterplan 2-29

²¹ District Data Book, p.14

²² According to the Chief of Sangkat 1

more serious. This damage also highlights the sensitivity caused by the nature of the housing; the assessment team has not been made aware of damage to brick built homes in other areas of the city. Houses similar to those in Tumnup Rolok are most likely to be destroyed; they often face directly onto the sea, are built with poor materials and foundations. These houses are home to the poorest residents

Community Perceptions of Vulnerability

The community members who participated in the focus groups were poor and lived in densely populated areas of the city, characterised by other socio-economic issues, such as lack of land tenure, low incomes, poor housing and limited water and sanitation facilities. The views of the community are expressed in the table below.

Table 1 shows sensitivity to climate change, as mentioned by the community. The hazards in the 1st column were presented by the group facilitators as points of discussion for the community. The exposures listed in the second column were largely suggested by the community as having either been experienced already or possible in the future. The sensitivity 'ratings' in the 3rd, 4th and 5th columns are based on the rating scores given by the community. The third column also considers the consolidated results of the trend analysis of previous effects of climate change and natural disasters. The table is designed to 'synchronise' with Table 5: The Cost of Business as Usual.

Table 1 - Sensitivity

Hazard	Possible or observed impact in urban areas	Level Of Sensitivity		
		Current	2025	2050
Sea Level Rise	Damage to fishing boats	Low	Low	Medium
	Damage to homes	Medium	Medium	Potentially High
	Coastal Erosion	High	Very High	Very High
	Damage to roads and infrastructure	Medium	Medium	High (very high in some places)
	Loss of agricultural land through sea-water incursion ¹	Low	Low	Low
Heat / Drought	Damage to homes	Low	Low	Low
	Heat related health problems	Medium	High	High
	Loss of livestock (and, thereby, livelihood sources)	Low	Low	Low
	Lack of potable water	Medium	High	High

	Damage to coral through increased exposure to sunlight	High	Very High	Very High
Storm Activity	Damage to housing (particularly roofs)	High	Very High	Very High
	Damage to fishing boats and equipment	High	Very High	Very High
	Damage to crops	Low	Low	Low
	Loss of tourism potential	Medium	Medium	Medium
	Increased threat from lightening	Medium	Medium	Medium
Flooding	Vector Borne Disease	Low	Medium	High
	Water Borne Disease	Low	High	High
	Damage to roads and other infrastructure	Medium	Medium	High
	Erosion and run-off from hilly ground	Medium	Medium	Medium
	Damage to homes	Medium	Medium	High

Adaptive Capacity to Climate Change in Sihanoukville

The Provincial Department of Water Resources and Meteorology collects basic weather data from its observation point in Sihanoukville. The forecasts are based on observations throughout Cambodia, satellite information and data from more advanced weather stations in Thailand and Vietnam. Presently, Cambodia does not have a Doppler Radar²³. This means that it is not able to forecast the weather to the same degree of accuracy as its neighbours. However, relying on their weather forecasts does not ensure accuracy either, given the increasingly localised nature of observed rainfall²⁴, in particular. This, coupled with a lack of technical capacity at the national level, also means that Cambodia does not produce its own emissions based climate model.

Neither the ministry nor the provincial department has any equipment for marine monitoring of weather or oceanic conditions at present. The Department of Meteorology believes that, in order to accurately predict local weather conditions, and in particular to provide storm warnings, marine based monitoring stations would be required, similar to those in Thailand.

Land Management and Building Regulation

At present, no cohesive strategy for land management, urban planning or building regulation is in effect locally. All titles and permissions to build are awarded on an individual basis, which means that the nature of new buildings is often ad hoc and does not conform to an overall masterplan. Land use planning and the Urban Masterplan have been prepared, in draft, with assistance from the Japanese International Cooperation Agency, but have yet to receive approval at the national level.

One possible outcome of unregulated construction is the increased trend toward ‘black water’ – or rainfall which causes localised flooding through not draining properly²⁵. This is because in order to fulfil the rapidly growing demand for hotels and other tourism facilities in the city, land which was previously green space has been used for building in an unplanned way²⁶. This means that the absorptive capacity of the land has been lost. In turn, new buildings do not consider this loss of absorptive capacity and their developers are neither incentivised, nor required to by law to do so.

Infrastructural Capacity – Water Supply

The water supply system currently only serves 23,400 customers in the urban area, around 32% of the total²⁷. Improving the number of homes with access to water is therefore a key challenge for the city. At present, the city obtains its water from a number of different sources; primarily Boeung Prek Tup, and Kbal Chay.

²³ Oum Ryna, Acting Director, Department of Meteorology, MoWRAM

²⁴ No scientific study has been conducted on this, but this is the informal observation of DoM

²⁵ Identified in the Community focus Group at Ochheateal Beach, April 2nd 2011

²⁶ Japanese International Cooperation Agency, 2010, Masterplan for Preah Sihanouk, Summary, part 2, p.13

²⁷ JICA, 2010

Source Name	Note	Capacity (m3 per day)	Annual Production Potential (MCM ²⁸)
Boeung Prek Tup	5 wet months	3,500	2.02
	7 dry months	8,000	
Kbal Chay		66,800	21.94
Well 1		720	0.24
Well 2		720	0.24
Well 3		600	0.20
Total		80,340	25

The Kbal Chay reservoir is modern, with a water treatment facility on site. The area surrounding the reservoir is a protected forest and, despite its proximity to the city, is in a remote area. The reservoir works on a water balance model, based on variations in the dry and rainy seasons, using data gathered from Sihanoukville city. It is estimated that the current water supply infrastructure can meet the needs of the city until after 2030. However, it is not known how changes in rainfall pattern, volume and seasonality will affect the facility. The Japanese report suggests that only 37.7% of the urban population have access to safe drinking water.

Sewage

Sihanoukville has separate systems for treating sewage²⁹ and for rainwater drainage. At present the lack of connection to the city system represents a problem – only around 1000 families are connected to the city infrastructure³⁰. The remainder use their own septic tanks or concrete pits. The Provincial Department of Public Works and Transport acknowledges that some of these families then drain their storage tanks into the sea or other water sources, but do not have an estimate of how many do this.

There are numerous issues relating to sewage in the city at present

- There is no legal framework or mandate for people to be connected to the city sewage system^{31,32}.
- The existing city sewerage system was only designed to serve a population of around 38,000, and, if extended to its future potential capacity, can only serve a population of 89,000^{33,34}.
- As a result, there are several areas where sewage is discharged into the sea. This has knock-on effects on marine resources³⁵.

Rainwater Drainage

The Provincial Department of Public Works and Transport have suggested strongly that the current system of rainwater drainage is inadequate. At present, the city has a network of 0.6 metre rainwater drainage culverts³⁶. These culverts are essential for safe removal of surface water, particularly given

²⁸ Million Cubic Metres

²⁹ The two are used interchangeably here

³⁰ According to Chhouk Kimseang, Deputy Director, Sihanoukville Department of Public Works and Transport

³¹ JICA, 2010, 2-54

³² Chhouk Kimseang, Deputy Director of DPWT, under Interview 26th April, 2011

³³ JICA, 2010, 2-54

³⁴ Chhouk Kimseang op cit

³⁵ See Marine Conservation Cambodia's recent assessment of coral and seagrass

³⁶ Nop Heng, Director, Provincial Department of Public Works and Transport, under interview, 26th April 2011

Figure 8 - Solid Waste in Sihanoukville



like this one are common throughout the city. Here the drainage culvert can be seen running from top left diagonally down to the right. Solid waste, which is supposed to be located in and collected from the brick storage in the top centre, is strewn around the vicinity, including in the drainage culvert, drastically reducing its effectiveness.

Increased standing water can lead to several problems; it is an ideal breeding ground for the *Aedes Aegypti* mosquito, which carries Dengue Fever. The Health Department has managed to get Dengue levels fairly low, to around 100 cases per year³⁸ in 2010. Increasing amounts of standing water will place great strain on the Health Department however, whose resources are limited. Given the proximity of large amounts of waste and flood water to densely populated residential areas, other health problems, such as water borne disease, may also become an issue. The Health Department has invested great human and financial resources to get Cholera and Acute Diarrhoea under control, but this progress is threatened by increased standing water, which is likely to increase due to greater rainfall, through climate change and poor waste management.

Solid Waste Management³⁹

Solid waste is managed by a private contractor, Cintri. However, certain areas of the city are not covered by the company, such as Otres beach on Sangkat 4. In many areas, waste collection points are not provided, and levels of awareness among communities are low.

Two significant problems exist with the current garbage collection system in the city. 1) Provincial Hall has no mechanism to ensure that the contractor delivers its outputs, which effectively means it has no legal enforcement mechanisms, and 2) The company has the contractual right to charge households for waste collection. The culmination of this is a situation is that garbage is often dumped at the side of the street by individuals, the company cannot prevent this and Provincial Hall has no mechanism to mandate Cintri to remove it.

³⁷ *ibid*

³⁸ Provincial Department of Health Statistics

³⁹ Picture in Figure 8 © UN-HABITAT/Liam Fee

Adaptation at household and community level

In terms of housing, specific autonomous adaptation at individual or community level has been relatively minimal. The adaptive benefits of traditional Cambodian stilted houses are reduced when facing the ocean as the elevation does not defend the house from storm surges or high winds. Throughout the assessment team's discussions with the communities, damage to homes, particularly roofs, was mentioned numerous times, but no community members suggested adaptation measures that they have undertaken autonomously, and the assessment team could not find any significant evidence of measures already undertaken.

There was significant variation of the experiences of community members on the effect of climate change on livelihood practices, with some failing to envisage what effects future climate change could have while others were able to make clear linkages between future risk and current livelihood practice but were unsure of the best course of action for adaptation. Many of the traders the assessment team spoke to, especially women, told us that they have frequently switched between different types of foodstuff and handicrafts depending on the season and local market conditions. The ability of local traders to change products and not to be 'tied' to one type of good represents a form of autonomous adaptation.

There has been some evidence of autonomous adaptation in tourism-focused livelihood activities with some initial moves being made to broaden the appeal of the city away from beach-based tourism. As documented earlier, there have been moves to provide sub-aquatic activities. However, broader diversification of tourist attractions in the city would be akin to autonomous adaptation, by reducing the dependence on the beach, which this report finds is already being negatively affected by the impacts of climate change.

Adaptive Capacity in Social Systems

In the UN-HABITAT community focus groups, none of the respondents directly referenced the negative (or positive) impacts of climate change on social relations. A significant development challenge in Cambodia is the lack of social safety nets. In the absence of such systems, social capital becomes more important, as social networks and informal institutions provide services the state is unable, or unwilling, to provide. While informal networks and institutions are widespread in Sihanoukville, and Cambodia more generally, the legal bonds connecting these can be weak. For example, in many communities, including those in Sihanoukville, there are informal loans mechanisms called *creditors*, which have the potential to be used for strengthening resilience by, for example, increasing livelihood options and strengthening housing. However, these are largely governed by bonds of trust, rather than formal legal instruments, and leave the urban poor open to 'shocks' such as natural disasters and the adverse effects of climate change.

Exacerbating Factors

Climate change should not be seen in isolation. Instead, climate change is at its most damaging to communities when it interacts with existing economic, social, or environmental problems. Therefore, the table below identifies issues which were highlighted by the local communities or the assessment team which would enhance adaptive capacity under one or more climate risk, or do not specifically address a climate risk, such as wealth creation, or issues which are not caused by climate change, but where climate change will increase or exacerbate their effect on local communities through reducing their adaptive capacity.

Table 3 - Exacerbating Factors

Economic/Social/ Environmental Problem	Impact/Exacerbated How?	Vulnerable Groups ⁴⁰	Options for Adaptation	Severity ⁴¹		
				2011	2025	2050
Low Incomes	Through potential reductions in income from fishing and tourism	The poorest, especially women (including Female Headed Households), the elderly and those without secure tenure	Livelihood diversification	Medium	High	Very High
	Because low income families tend to live in poor quality/temporary accommodation and without tenure		Small scale home agriculture/aquaculture	High	High	High
	Combining with low education levels reducing livelihood options		Secure Tenure Urban planning which incorporates the need to protect low income communities from hazards (the sea, land at risk of erosion, streams and rivers)	High	High	High
Waste Management	Solid waste blocking storm drains, canals and watersheds. Under climate change rainfall is predicted to increase, leading to increased problems of flooding ⁴²	All residents	Education – awareness of littering	Medium	High	High
			Providing garbage facilities (bins) End the contractual dispute with Cintri/find another waste management contractor	Medium	High	High

⁴⁰ In some cases, where the effect on the poor is specific, it is highlighted, however, in all other cases, it should be assumed that the poor will be more seriously effected

⁴¹ Assumes that anticipated climate change scenarios will occur, with no action taken to alleviate social, environmental or economic problem

⁴² See 'Flooding' section of the direct impacts table

Pollution	Marine pollution causing declines in fish Damage to coral and sea grass. Climate change also degenerates these through exposure to heat and sunlight	Primary – Fishermen Secondary – People who purchase fish, particularly the poor, through rising prices. Tourist businesses	See waste management options, above, much solid waste ends up in the sea Prohibit, punish and, if necessary, evict beach-front businesses who pollute the sea	Medium	High	Very High
				Low	High	Very High
Gender	Increase in water/vector borne diseases and other health problems – women often have primary roles as carers Incomes affected more greatly – women rely on home for incomes, with homes likely to be damaged by climate change	Women, particularly the poor, Female Headed Households and the elderly	Gender oriented urban planning, Provision of healthcare facilities Specific training for women	Low	Medium	Medium
				Medium	Medium	Medium
Ecosystem Services	Relative lack of natural storm/sea-water defences Loss of surface ‘permeability’ Lack of planning encroaching on forests or wetlands	The poorest, those living close to the sea	Investigate possibility of planting mangrove/natural sea-defences See waste management Environmentally aware urban planning.	Low	Medium	Medium
				Medium	Medium	Medium
				Medium	High	High

While table 3 gives us very useful information about the nature of vulnerability in Sihanoukville, the assessment team felt that the communities did not mention all the possibilities, knock-on effects and impacts of climate change. This presented the team with a problem, because if a community is not aware of a climate related problem, or has not experienced it, then how can they describe and rate their vulnerability to it? We found that, in particular, the communities were unable to relate 'secondary', or knock-on issues to their own lives, such as impact on food supplies and ecosystem services.

Table 4 - Secondary Climate Threats

Climate Risk	Additional/Secondary Impact	Vulnerable Groups	Options for Adaptation	Urgency to act
Increased temperatures	Heat related diseases – Dehydration	The young, the elderly, the sick, pregnant women	Education/awareness raising	Medium
	Cardiovascular problems		Better access to clean drinking water	
	Respiratory problems			
	Increased requirement for cooling	The poor, local businesses, the local government	Better ventilation, possibly through building regulation and urban planning	Medium
	Declining air quality	All, particularly the young, the old and those with pre-existing health conditions		
	Fish species migration ⁴³	Local fishermen, the poorest, local businesses	Change to catch more abundant local species, increase aquaculture and fish 'farming', increase fishermen capacity, build capacity of local authorities to better understand migratory patterns	High

⁴³ The likelihood of this is not known, as migratory patterns are not well understood locally

Drought	Loss of/decline in agricultural production, leading to rising food prices ⁴⁴	The poorest, landless people, local restaurant businesses	Climate resilient agriculture through better water management and infrastructure	Low ⁴⁵
	Stress on fresh water supply and/or requirement to import water	The poorest	Better management of water, capture and storage ⁴⁶ Infrastructure protection maintenance and upgrading	Medium
Rainfall	Increased standing water, exacerbated by reduction in absorptive capacity	The poorest, those who live on or at the bottom of slopes	Building codes and design which captures and stores rainwater. Improved drainage and waste management	High
	Water Supply	Only affects those connected to water supply – 32%. However, could affect hospitals and other public services	Technical assessment of water supply infrastructure	High
Sea level rise	Changes in ground water, caused by shifting rainy season	The poorest – those who depend on small-scale wells and pumps for water	Further assessment to understand impact of future rainfall. Connection city system ⁴⁷	High
	Salination – causing damage to coastal water tables	Those who depend on fishery or the ecosystem services provided by the damaged area, often the poorest	Mangrove and natural coastal defences, strengthening ecosystem services and protecting and managing these	Medium

⁴⁴ While the city itself does not produce much food through agriculture, the wider province – and Cambodia more generally – does. This is an adaptation option which would require to be undertaken at a wider provincial level, and in close coordination with national actors working on rural adaptation

⁴⁵ Low in the city, though in other areas of the country the urgency to act on this issue is much higher

⁴⁶ Sihanoukville experiences two-and-a-half times the average annual rainfall for Cambodia – supplying fresh water ought not to be a challenge, even under an extended dry season.

⁴⁷ Assuming that the city water supply system is more reliable and resilient than small scale pumps

The second table considers options for adaptation and, unlike much of the rest of the report, it also considers actions to mitigate carbon emissions. However, in the long run, particularly regarding land use and/or urban planning, and considering likely future growth in the Cambodian economy, which will include polluting industries, actions to mitigate climate change emissions are worth considering.

6 Analysis and Recommendations

Business as Usual

Business as usual represents the likely impact of what will happen if no action is taken to adaptation (if only autonomous, and not planned adaptation) takes place. Therefore, business as usual has to be derived from where sensitivity is highest and where adaptive capacity is lowest. According to the data gathered in the course of this report, business as usual can be summarised as follows. Note that only 'High' or 'very high' sensitivity areas are considered here:

Table 5 - Business as Usual

Climate Risk	Impact	Probable future Severity (2025)	Probable future Severity (2050)	Cost of business as usual
Sea Level Rise	Damage to homes	Medium	High	Up to 2000 families affected, landlessness, forced re-settlement, loss of livelihood opportunities
	Coastal Erosion	High	Very High	Total loss of beach, causing loss of significant livelihoods through tourism, some loss of Habitat, damage to houses and infrastructure (through damage to foundations)
	Damage to roads and infrastructure	Medium	High	Economic losses, diversion of government/donor financial resources, increased accidents, pollution from noise/dusk
Heat and Drought	Lack of potable water	High	High	Health problems through drinking unsafe water
	Damage to coral through increased exposure to sunlight	High	High	Loss of coral, leading to loss of fish and damage to fishery livelihoods. Affect on tourism and water quality
	Heat related health problems	Very High	Very High	Dehydration, poor people and those without regular access to safe drinking water affected

Storms	Damage to fishing boats and other livelihoods	Very High	Very High	Loss of livelihood, loss of life (already reported)
	Damage to housing (particularly roofs)	Very High	Very High	Economic losses to the poorest – often live in the lowest quality homes, potential safety issues, loss of livelihood opportunities
Flooding	Vector Borne Disease	Medium	High	Possible increase in deaths among already vulnerable, loss of livelihoods
	Water Borne Disease	High	High	See above
	Damage to roads and other infrastructure	Medium	High	Economic losses, diversion of government/donor financial resources, increased accidents, pollution from noise/dusk
	Damage to homes	Medium	High	A significant number of families possibly affected, loss of livelihoods

High Priority Areas and Issues

1. **Tumnup Rolok⁴⁸** Rather than try to de-lineate the complex amalgam of challenges currently being faced by the Tumnup Rolok area, the report instead finds this location, in and of itself, to be a high priority target area. Because of the geography of the area – low lying, densely populated, at the edge of the city, separated from it by the port – Tumnup Rolok's unique vulnerabilities can be seen in isolation from the remainder of the city. The primary factors driving Tumnup Rolok's vulnerability are as follows:
 - a. Its proximity to the sea, and sub 1metre elevation
 - b. The general vulnerability of fishery livelihoods to climate change, though poor quality fishing boats and impacts on fish populations
 - c. Its dense population, who do not have secure tenure
 - d. The lack of reliable weather and storm information available to local people, particularly fishermen
 - e. Waste management and local level pollution, which in turn causes health problems, poor water drainage, and marine pollution, and which in turn is at risk of 'exacerbation' through climate change
 - f. Water supply and sanitation services

⁴⁸ Tumnup Rolok is indicative of the living conditions for all urban poor in Sihanoukville

The priority actions here are, therefore, as follows;

As part of the urban Masterplan process, a social land concession relocation site should be sought. This is a process which is already underway, but more ‘completeness’ should be added by having a more participatory process with key stakeholders, including the community themselves, using the ‘Circular 3’ implementation mechanism. It is likely that there will be initial resistance from community members, so the government should consider this a long term (i.e. 30 year) strategy, moving the most vulnerable and/or those wishing to leave first. Climate change is not a justification for relocating the community at present, but it poses increasing risks to them in the long run.

2. Governance and Service Provision Issues

Sewage, drainage, waste management and urban planning are all priority areas for the city, and effective management of each will increase resilience to climate change. Finalising, approving and implementing the urban Masterplan should be a priority for the city. Cities without urban Masterplans are commonly seen to be more vulnerable⁴⁹ to climate change and the Masterplan should be a vehicle through which Sihanoukville can achieve a vision for strategic urban development over a period of, say, thirty years.

An urban Masterplan, whose provisions are developed and implemented with partnerships between stakeholders (including vulnerable communities) also offers find synergies between adaptation and mitigation, which will become increasingly important in the long run, as the city economy moves toward more polluting industries. The Masterplan should also consider building codes and regulations, which will ensure that new, large scale developments – particularly for industry, the Port and tourist facilities (large hotels, etc) are designed in a way so as to both reduce climate vulnerability and ‘carbon footprint’ through energy efficiency.

In the long run, the assessment team feels that, regarding drainage, grey-water recycling is a much more cost effective adaptation option than improving drainage infrastructure, which has a high risk of being maladaptive. The assessment team feels this has the potential to be highly maladaptive because the water drained into the sea has a high chance of causing marine pollution, thereby damaging coral and sea-grass and ultimately the local fishing and tourism industries. The cost of a new drainage system whereby water does not drain into the sea has not been estimated, but is likely to be far higher than the existing \$10million estimate for improvements.

Sewage is also a high priority for the city, and effective management of it is key to adaptation. Many families still pump sewage into local water sources, which ultimately ends up in the sea. Climate change, bringing increasing flood risks, stands to exacerbate this. Given that nearly 70% of families don’t have a connection to the city system, connecting them should be a priority short term action, including getting connections to those for whom they are not currently available, such as in Sangkat 3. In the long run, improvement of the sewage infrastructure should be considered and incorporated into the Masterplan.

⁴⁹ See, for example, Dodman, 2009

Waste management is also a priority, because this mixes with rainwater in the drainage system (as well as causing blockages) which ultimately means it either ends up in the sea, or pollutes residential and business areas. Increased flood risk under climate change will exacerbate this problem. The city should consider a three pronged approach on this; firstly it should continue and scale up the advertising, awareness and education programmes it currently has to raise awareness about littering and improper waste disposal on behalf of individual households. Secondly, the contract with the private firm must be renegotiated, putting Provincial Hall in a stronger position to demand results, while ultimately being accountable to communities, especially the poorest, who are hardest hit by solid waste issues. In order to do this, a Public Private Partnership model, as identified above, should be studied further, citing successes in other cities. Thirdly, a legal framework should be in place which punishes those who litter, the company if they fail to collect waste and provide better facilities for waste disposal (green 'bins' for example).

Capacity Development and Planning

Capacity development of all actors involved in climate change in Sihanoukville should be an ongoing, cross-cutting priority. Capacity is low across the board, particularly on the technical aspects of climate change among local government staff. Project implementation capacity was found to be good, thanks to the ongoing PEMSEA initiative, but any future UN-HABITAT involvement in Sihanoukville should seek to work closely with PEMSEA, particularly in this regard. Community capacity, particularly in the poorer areas of the city, is very low. Raising this; awareness of the problems, other, related environmental issues and behaviours which can avoid risk and increase resilience should also be a priority. The Department of Environment in conjunction with the Department of Public Works and Transport does some of this work, and has had limited success, but it should scaled up in a coordinated manner.

The outcomes of immediate work undertaken in this assessment and, ideally, simplified versions of its methodologies could be mainstreamed into the commune development plans, which are being coordinated by the Department of Planning). The assessment does not make findings which are directly relevant to the process per se, but climate change ought to be mainstreamed into this process, and this is in line with national policy objectives.

Overall, Sihanoukville is vulnerable to climate change, which presents increasingly serious challenges in the future. However, when viewed in the wider context of linked environmental, social and economic problems in the city, climate change poses a serious risk of exacerbating these problems. As a result, the priorities recommended here may be seen to be quite general. However, they are presented in such a way because they are designed to offset the wider issues, rather than just climate change, which should not, and can not, be delineated. The priorities identified here are strategic ones, which, if acted upon, will enable the city to develop in a sustainable, climate resilient way.

3. Livelihoods and Eco-system services

Tourism in Sihanoukville is highly vulnerable to climate change due to its dependence on climate sensitive attractions – primarily its beaches, but also water sports, including diving. To an extent, the projected extension of the dry season presents an opportunity to the local industry, but it is unlikely to

offset the losses caused by erosion of the beach, loss of marine resources/pollution and reductions in tourist numbers during the rainy season.

The loss of beach to sea-level rise and erosion is a pressing concern. More research needs to be done on preventative measures in this area. One option for further study is artificial extension of the beach and/or re-enforcement of the existing sand. The costs of this may be prohibitive however, but it should be considered as an option and thus studied further, possibly as part of the Masterplanning process. The governance issues, addressed above, will also serve to strengthen livelihoods, including tourism.

Fishing will continue to be a primary source of income for many families. There needs to be ongoing work at the local level to understand the impacts of climate change on fish stocks and there is room to integrate this with continued monitoring of coral and sea-grass in the immediate offshore area. Improved weather information services will ensure that fishermen are equipped to make more informed decisions about when and where to fish.

Market traders, particularly those who trade foodstuffs, showed some autonomous adaptation in their ability to switch goods relatively easily. Many of the food products traded come from the nearby rural areas, so a provincial level action plan which ensures increased rural adaptive capacity to climate change would have secondary benefits for the city.

