CITIES AND CLIMATE CHANGE INITIATIVE

SIHANOUKVILLE, CAMBODIA: CLIMATE CHANGE VULNERABILITY ASSESSMENT



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SIHANOUKVILLE, CAMBODIA: CLIMATE CHANGE VULNERABILITY ASSESSMENT

Abridged Report on Climate Change Vulnerability in Sihanoukville Municipality
Research, Analysis, Findings and Recommendations
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Sihanoukville, Cambodia: Climate Change Vulnerability Assessment

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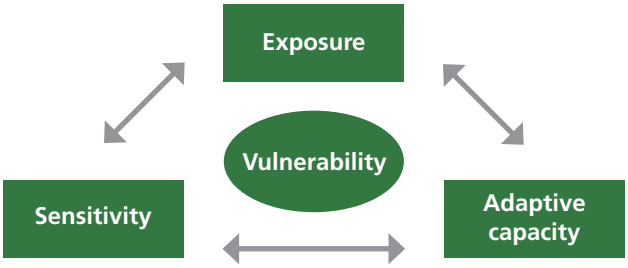
Contents

1.0

Overview

The 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 were used in order to establish this: first, a substantial policy and document review. Second, extensive and in-depth interviews were held with a variety of stakeholders at national and local levels. Finally, in-depth vulnerability assessment focus groups were conducted with several communities in Sihanoukville. The assessment also considered stakeholders such as the private sector and non-governmental organizations; and issues such as climate science, economic and urban planning, as well as the link between climate change and environmental concerns 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 Programme for South-East Asia, Cambodia, along with the Philippines, is the most vulnerable country to climate change in South-East Asia[1]. 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-levels of income; skill and infrastructure. Relatively little assessment has focused on urban areas in Cambodia, which is partly due to the widely-held perception



that the population is predominantly rural. However, a recent report by the Ministry of Planning puts the urban population at 27.1 per cent[2].

1.1 ASSESSMENT FRAMEWORK

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

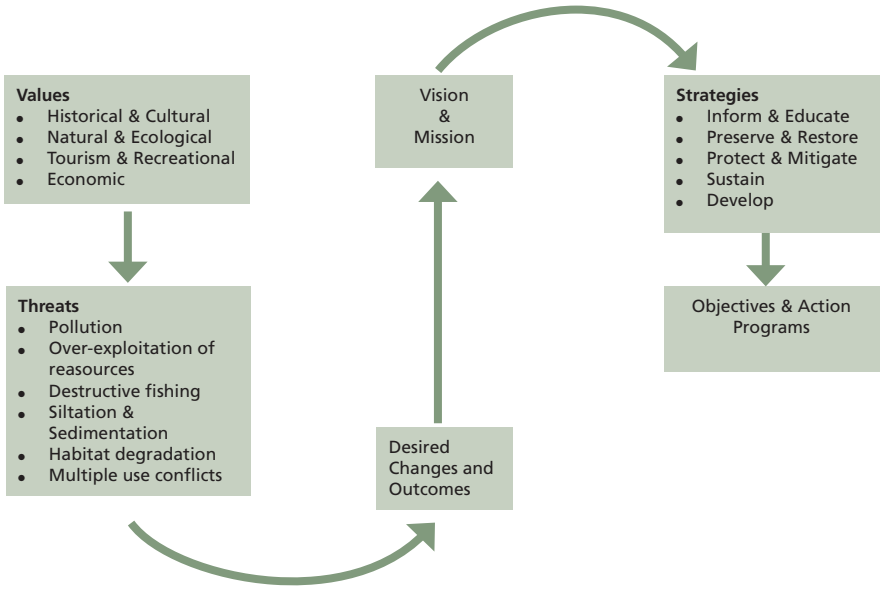
1.2 POLICY CONTEXT

Climate change is dealt with in numerous policies that the Royal Government of Cambodia has adapted. Cambodia ratified the United Nations Framework Convention on Climate Change in 1995 and acceded to the Kyoto Protocol in 2002. Also in 2002, the national Government, through the Ministry of Environment, published the Initial National Communication to the Convention. 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

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

2 *Reclassification of Urban Areas in Cambodia, 2011, National Institute of Statistics, Ministry of Planning*

Figure 1: Coastal Management Strategy



Source: Sihanoukville Coastal Strategy, 2002, p.24

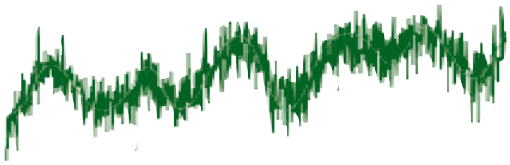
Adaptation Programme of Action, detailed in Section 4, carried this forward and was published in 2006. This programme of action recommends various project actions, though only now are these beginning to take place and their implementation remains patchy.

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. The Ministry of Environment is preparing a national strategic action plan for climate change.

The above diagram shows the process flow of the coastal strategy. While some of the threats identified in the coastal strategy relate to the scope of this report, its planning process took place in 2001. Rapid development has taken place since then (partially according to the strategy), limiting its relevance. This report, therefore, does not rely heavily upon the coastal strategy.

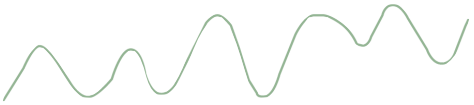
The Provincial Environmental Management Plan, spanning 2011-2015, has also been prepared. This document remains in draft form and has yet to be finalized, approved or incorporated. Presently, the provincial government is deciding whether or not the draft should be realigned to become an overarching "sustainable development plan". However, the draft does not make extensive provisions for climate change and, given that as of May 2012, the plan had still not been officially approved, it is unlikely to be adopted.

Figure 2: Fluctuations in weather patterns in a given period



Source: GIZ (2009) Climate Change Information for Effective Adaptation; A practitioner's Manual, p.13

Figure 3: Fluctuations in climate patterns over the same period



Source: GIZ (2009) Climate Change Information for Effective Adaptation; A practitioner's Manual, p.13

1.3 WEATHER AND CLIMATE

Distinguishing weather from climate was vital to the assessment. Such a distinction raises awareness with local stakeholders and generates useful data from communities. Weather is the day-to-day state of the atmosphere in terms of temperature, moisture content and air movements.[3] Weather is therefore something observable, which can change over the course of a few hours, days or weeks.

Climate, however, is a scientific concept measured using an aggregation of weather data or statistics collected over time (at least 10 but more often 30 years). Climate, therefore, is not 'conceivable' in the minds of individuals, whereas weather is. This creates a challenge in community-level vulnerability assessment 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).

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

2.0

Climate Change Exposure

Due to its location on the coast, its proximity to the Cardamom Mountains and the influence of an inter-tropical convergence zone, Sihanoukville has significantly higher rainfall than many other parts of Cambodia. According to the United Nations Food and Agriculture Organization, average annual rainfall for Cambodia is estimated to be around 1,400mm[4]. In Sihanoukville, average annual rainfall in the period 1983-2011 was 3,198mm[5], more than double the national average. The outcome of this is that Sihanoukville experiences heavier rainfall than much of the rest of Cambodia, compounding the pressures on the city's infrastructure and residents. Flooding, drainage issues and waste water management are of particular concern.

While it is difficult to observe a distinct trend in local rainfall patterns, it is clear that 2009 and 2010 are the first and second driest years since recording began. National rainfall data since 1960 coincides with local data (shown in Figure 4) in that there does not appear to be any consistent increase or decrease in rainfall since 1960.

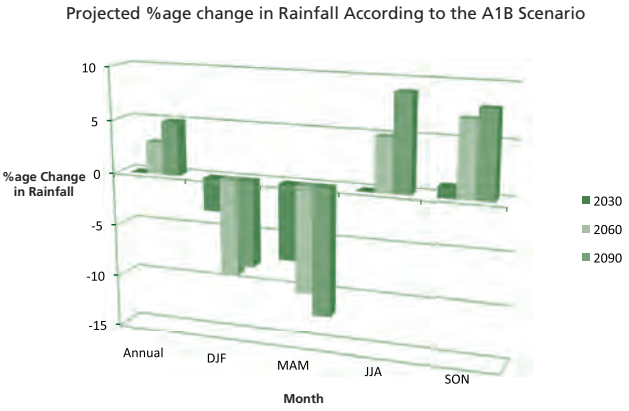
Likewise, the amount of rainfall that occurs in "heavy" events shows no consistent increase or decrease. In 2011, there was significantly more rainfall than in 2009 and 2010.

Future projections of rainfall are again quite inconsistent, though the general consensus suggests 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 that will occur in "heavy" events is projected to increase by up to 15 per cent. This indicates that storm intensity will also increase.

Figure 4: Project percentage change in annual rainfall

Source: Preah Sihanouk Provincial Department of Water Resources and Meteorology

Figure 5: Annual Rainfall



Source: McSweeney, New and Lizcano, 2010, UNDP Country Climate Profile

4 *http://www.fao.org/nr/water/aquastat/countries/cambodia/index.stm accessed 412/4/2011*

5 *Provincial Department of Water Resources and Meteorology statistics*

2.1 SEA LEVEL RISE

Localized measurement of observed sea level rise does not yet exist in Cambodia. Local mean sea 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. Although there are several causes of sea level rise, thermal expansion (increase in water volume with heat) is presently considered to be the leading cause[6]. The melting of glaciers and polar ice sheets may become more significant in the future, depending on greenhouse gas emissions and future temperature increases. 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 1 metre per century[7].

Between one and two metres of sea level rise could have severe local impact, particularly for the low-lying Tumnup Rolok community, which is home to many of Sihanoukville's urban poor. This is exacerbated by tidal variation, which can be up to 0.7 metres per day.

Sangkat Muoy © UN-Habitat/Liam Fee

2.2 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 will be the most exposed to strong winds in the future[8]. 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 six metres are possible, while winds of that strength may damage homes with thatched or fibro roofs.

According to satellite data observed between 2006 and 2008, waves of four to five metres high, while moderate compared to some other parts of the region, could have serious knock-on effects for the low elevation areas of the city. This is particularly dangerous for marine fishermen, who spend long periods of time at sea in poor quality fishing boats.

2.3 TEMPERATURE CHANGE

Nationally, the mean average annual temperature has increased by 0.18°C since 1960. The change is more pronounced in the dry season (November to May) with an average change of up to 0.23°C. The change in the wet season is slower, ranging between 0.13 and 0.16°C. The frequency of "hot" days and nights - defined as where the temperature is 10 per cent 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 and nights - defined as where the temperature is 10 per cent or more below the average for that month - has decreased sharply[9].

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

7 *ibid*

8 *Ministry of Environment, Second National Vulnerability and Adaptation Assessment Report*

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

3.0

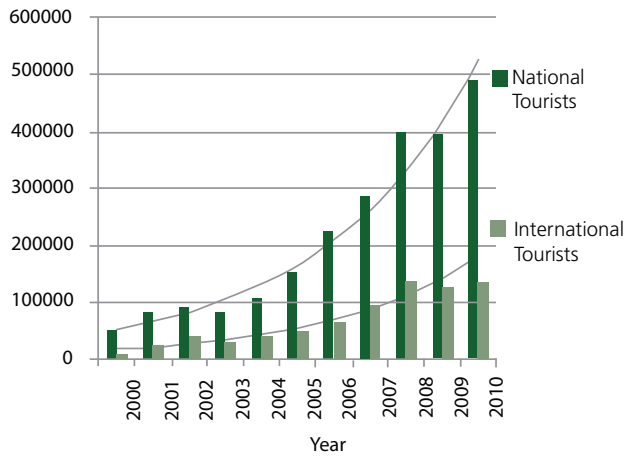
Climate Change Sensitivity

3.1 SENSITIVITY IN KEY INDUSTRIES, LIVELIHOODS AND ECOSYSTEMS

3.1.1 Tourism

Tourism is an important industry for Sihanoukville, from which up to 60 per cent of the population derives some or all of their income. Tourism has also become an important sector in the economy, and since 1999 there has been a rapid increase in the number of foreign and domestic tourists to Cambodia.

Figure 6: Tourist Arrivals in Sihanoukville



Source: Based on data provided by the Preah Sihanouk Provincial Department of Tourism

The sensitivity of tourism to climate change is mixed and unique from other industries. Sea level rise presents a serious threat to the existence of the industry primarily due to beach erosion. The potential to protect beaches remains unknown given the lack of precedent and probable complexity of engineering. Sea level rise could also jeopardise tourism to the islands for a suite of related reasons. The infrastructure required to protect the beaches against sealevel rise is also likely to be prohibitively expensive.

Unlike other industries, tourism has the potential to benefit from the projected seasonal shift[10]. A longer dry season would mean an extension of the high season for Sihanoukville. However, capitalizing on this is difficult. Rainfall data shows that there has been little observable shift so far: perhaps the only observable change is that rainfall has been declining in May and June. This would echo the predictions being made about seasonal shift in Cambodia[11] but still represent a challenge in terms of encouraging tourism during these months. Given that livelihoods and job creation are dependent on tourism in the city, attracting tourism would generate income and increase adaptive capacity.

Tourism is already affected by storms
© Provincial Govt of Preah Sihanouk Province/Prak Visal

10 National Adaptation Programme of Action (2006)
11 ibid

3.1.2 Fisheries

According to the Sihanoukville District Data Book, in 2008 10 per cent of families in Sihanoukville derived their primary income from fishing[12]. In terms of livelihood, fisheries are economically sensitive to damage or destruction of fishing vessels and equipment, as well as loss of life, due to storms. In each of the previous two years boats have sunk at sea, resulting in deaths.

The assessment team was unable to estimate the economic cost of fishing boat losses. Many of the boat piers in Sihanoukville are privately-run, and often on the black market, making official data gathering difficult. The present lack of accurate weather forecasting for fishermen compounds their vulnerability, permitting them to fish at times and in areas which may be unsafe. In tandem with a possible future scenario of increasingly unpredictable storms and higher wave heights, marine fisheries are particularly economically sensitive.

3.1.3 Marine Ecosystems

Sihanoukville's marine ecosystems are highly sensitive to human activity, including the impacts of climate change. Of great significance is the presence of coral reefs. Corals support many other forms of aquatic life which, in turn, are an essential source of livelihood and commercial activity. A Ministry of Environment assessment found the condition of Cambodia's coral reefs to be generally poor[13]. There are large areas of coral reef off the coast of Sihanoukville, much of which are close to the shoreline and which local fishermen frequent. Coral reefs also provide protection to the coastal zone from the impacts of sea level rise, including sedimentation. The reefs are also potentially attractive to divers and snorkelers.

The main climate change threat to corals is "bleaching"; however, a recent report found levels of bleaching to be low. Only around 7 per cent of the local coral population surveyed was found to be bleached[14]. Because the negative effects of coral bleaching are difficult to reverse once they take effect, there is now an opportunity to prevent damage to corals and prevent future losses. The effects of coral bleaching can also be classed as highly sensitive because they have wide-ranging impacts on the livelihoods of local people. The impact on fish populations will, for example, adversely affect quality and diversity of fish available to local people, damaging their livelihoods. Bleached and damaged corals could also affect the growing number of snorkelers and scuba divers visiting the area who represent an important facet of the tourist industry.

3.2 SENSITIVITY IN INFRASTRUCTURE AND HUMAN SETTLEMENTS

3.2.1 Infrastructure

Unsealed roads are 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. Community residents described the negative impacts of erosion and detritus to their homes and businesses, as a result of rainstorms on unsealed roads.

The Road from Sihanoukville to Stung Hav
© UN-Habitat/Liam Fee

Poor drainage is another issue on many roads that could become more serious in the future, should projected changes in rainfall occur. Many people who spoke with the assessment team said improved drainage was needed to prevent future problems.

12 *Krong Preah Sihanouk, District Data Book, 2008, p.18*

13 *Ministry of Environment, Second National Vulnerability and Adaptation Assessment Report*

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

The road to Stung Hav, pictured above, is an area of future industrial development and the site of a new port terminal. It is also under threat from sea level rise. A metre rise in sea-level would submerge sections of the road. The Japanese International Cooperation Agency has also identified the road as being inadequate. Although consideration has given to upgrading the road, no firm plans exist at present to do so[15].

3.2.2 Housing

In 2008, 78 per cent of houses in Sihanoukville had a zinc/fibro roof, while a further 3 per cent had thatched roofs[16]. 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 in the coastal area, such as Tumnup Rolok, are indicative of higher sensitivity because housing structures are less likely to be permanent or well-constructed and, therefore, in this area are especially vulnerable. Extrapolation suggests that informal settlements in Sihanoukville are generally more sensitive to climate impacts due to the nature of housing existing within them.

As this report was being prepared, in July 2011, a storm damaged 27 houses in Tumnup Rolok, destroyed seven others beyond repair and severely injured one person. This is in addition to a storm in May in which four houses were destroyed[17]. Deaths have been reported in previous years in the area and given the lack of forecasting and information, the risk to people in informal settlements is becoming 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, but houses similar to those in Tumnup Rolok are most likely to be destroyed; they often face directly into the sea, and are built with poor materials and foundations. These houses are home to the poorest residents.

3.2.3 Community Perceptions of Vulnerability

The community members who participated in the focus groups were poor and lived in densely populated areas of the city, characterized by other socioeconomic factors 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 first 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 third, fourth and fifth 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 "synchronize" with Table 5, "The Cost of Business as Usual".

15 JICA Master plan 2-29

16 District Data Book, p.14

17 According to the Chief of Sangkat

Table 1: Sensitivity

Hazard	*Possible or observed impact in urban areas*[18]	*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 seawater incursion	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

Source: Data collected in the field.

18 Those listed in green were suggested by the assessment team

4.0

Adaptive Capacity to Climate Change

4.1 WEATHER FORECASTING

The Provincial Department of Water Resources and Meteorology collects basic weather data from its observation point in Sihanoukville. National weather 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 radar[19]. This means that it is not able to forecast the weather to the same degree of accuracy as neighbouring countries. However, relying on their weather forecasts does not ensure accuracy either, given the increasingly localized nature of observed rainfall[20] in particular. This, coupled with a lack of technical capacity at local and national levels, 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 National Department of Meteorology believes that, in order to predict local weather conditions accurately, and in particular to provide storm warnings, marine-based monitoring stations similar to those in Thailand would be required.

4.2 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 master plan. Land use planning and the Urban Master Plan 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 localized flooding by not draining properly[21]. 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 without conforming to a master plan[22]. 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 have no incentive, nor are they required to by law to do so.

4.3 INFRASTRUCTURAL CAPACITY – WATER SUPPLY

The water supply system currently only serves 23,400 customers in the urban area, around 32 per cent of the total population[23]. The low number of homes with access to piped clean water supply can be seen as contributing towards low adaptive capacity of the city. At present, the city obtains its water from a number of different sources; primarily Boeung Prek Tup and Kbal Chay.

19 Oum Ryna, Acting Director, Department of Meterology, MoWRAM

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

21 Identified in the Community focus Group at Ochheauteal Beach, April 2nd 2011

22 Japanese International Cooperation Agency, 2010, Master plan for Preah Sihanouk, Summary, part 2, p.13

23 JICA, 2010

Table 2: Water sources in Sihanoukville

Source Name	*Note*	*Capacity (m^3 per day)*	*Annual Production Potential (MCM^{24})*
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	25.00

Source: Adapted from JICA, 2010, Master plan for Sihanoukville Municipality

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 . 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 per cent of the urban population have access to safe drinking water.

4.4 SEWAGE

Sihanoukville has separate systems for treating sewage[25] and for rainwater drainage. At present the lack of connection to the city system represents a problem – only around 1,000 families are connected to the city infrastructure[26]. 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 discharge 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[27,28]
- The existing 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[29,30]. This is slightly less than the current population
- As a result, there are several areas where sewage is discharged into the sea. This has knock-on effects on marine resources[31]

4.5 RAINWATER DRAINAGE

The Provincial Department of Public Works and Transport has suggested, strongly, that the current system of rainwater drainage is inadequate. At present, the city has a network of 0.6 metre-wide rainwater drainage culverts[32]. These culverts are essential for safe removal of surface water, particularly given the heavy precipitation events the city experiences. The drainage culverts carry all rainwater to the sea at present. In order to offset anticipated future rises in rainfall, the Department of Public Works and Transport estimates that the width of the entire network of drainage culverts needs to be extended to one metre, which will cost approximately USD10 million[33] and which the National Adaptation Programme of Action has been identified as a priority project.

Flooding in Sangkat Buon, central Sihanoukville © PEMSEA

24 Million Cubic Metres

25 The two are used interchangeably here

26 According to ChhoukKimseang, Deputy Director, Sihanoukville Department of Public Works and Transport

27 JICA, 2010, 2-54

28 ChhoukKimseang, Deputy Director of DPWT, under Interview 26th April, 2011

29 JICA, 2010, 2-54

30 Chhouk Kimseang op cit

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

32 NopHeng, Director, Provincial Department of Public Works and Transport, under interview, 26th April 2011

33 ibid

Solid Waste in Sihanoukville
© Liam Fee/UN-Habitat

Solid waste is a serious obstruction to the current drainage capabilities. Situations like that pictured above are common citywide. 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, a vector for dengue fever. The Health Department has managed to get dengue levels fairly low, to around 100 cases per year[34] in 2010. However, increasing amounts of standing water will place great strain on the Health Department, whose resources are limited. Given the proximity of large amounts of waste and flood water to densely-populated residential areas, other health problems, such waterborne disease, may also become an issue. The Health Department has invested a great deal of money and manpower to get cholera and acute diarrhoea under control. However, this progress is threatened by increased standing water, which is likely to augment due to greater rainfall through climate change and poor waste management.

4.6 SOLID WASTE MANAGEMENT[37]

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

Two significant problems exist with the current garbage collection system in the city: first, Provincial Hall has no mechanism to ensure that the contractor delivers its outputs, which effectively means it has no legal enforcement mechanisms. Second, the waste management company has the contractual right to charge households for waste collection. The culmination of this is a situation whereby individuals often dump garbage at roadsides. Cintri cannot prevent this and Provincial Hall has no mechanism to mandate the company to remove roadside garbage. The result is that solid waste often remains uncollected.

34 Provincial Department of Health Statistics

5.0

Adaptation at Household and Community Levels

In terms of housing, specific autonomous adaptation at the 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 protect homes from storm surges or high winds. Throughout the assessment team's discussions with the communities, damage to homes, particularly roofs, was mentioned numerous times. However, no community member suggested adaptation measures that they had undertaken autonomously, and the assessment team could not find any significant evidence of measures already embarked on.

There was significant variation of the experiences of community members relating to the effect of climate change on livelihood practices, with some failing to envisage the effects of future climate change. Others were able to draw clear links between future risk and current livelihood practice but were unsure of the best course of action for adaptation. Many of the traders with whom the assessment team spoke, especially women, said that they had 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 rather than be "tied" to one type represents a form of autonomous adaptation, as sellers will be able to withstand shortages of a certain type of good if that occurs.

There has been 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 previously documented, there have been efforts to facilitate sub-aquatic activities for tourists. However, broader diversification of tourist attractions in the city would represent autonomous adaptation by reducing the dependence on the beach, which this report finds is already being negatively affected by the impacts of climate change.

5.1 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. The government and development partners are looking to remedy this through the recently-approved National Social Protection Strategy. 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 offer. While informal networks and institutions are widespread in Sihanoukville, and in Cambodia more generally, the legal bonds connecting these are weak. For example, in many communities, including those in Sihanoukville, there are informal credit and lending mechanisms which have the potential to be used for strengthening resilience by increasing livelihood options and strengthening housing. However, these are largely governed by bonds of trust rather than formal legal instruments, leaving the urban poor open to "shocks" such

as natural disasters and the adverse effects of climate change.

5.2 EXACERBATING FACTORS

Climate change should not be seen in isolation. Instead, it is at its most damaging to communities when it interacts with existing economic, social or environmental problems. Therefore, the table below identifies issues which local communities or the assessment team highlighted, which would enhance adaptive capacity under one or more climate risks, or do not specifically deal with a climate risk. One example is wealth creation or instances in which climate change does not directly cause an issue but, instead, exacerbates existing challenges by reducing adaptive capacity.

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 unaware of a climate-related problem, or has not experienced it, then how can they describe and rate their vulnerability to it? In particular, we found that 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 considers options for both adaptation and actions to mitigate carbon emissions. In the long run, particularly regarding either land use or urban planning, or both, and considering likely future growth in the Cambodian economy, which will include polluting industries, actions to mitigate climate change emissions are worth considering.

Table 3: Exacerbating Factors

Economic/ Social/ Environmental Problem	*Impact/Exacerbated How?*	*Vulnerable Groups*[35]	*Options for Adaptation*	*Severity*[36]		
				2011	*2025*	*2050*
Low Incomes	Through potential reductions in income from fishing and tourism. Because low-income families tend to live in poor quality/temporary accommodation and without tenure. Combining with low education levels reducing livelihood options.	The poorest, especially women (including female-headed households), the elderly and those without secure tenure.	Livelihood diversification. Small-scale home agriculture/ aquaculture. 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).	Medium High High	High High High	Very 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[37].	All residents.	Education – awareness of littering. Providing garbage facilities (bins). End the contractual dispute with Cintri/find another waste management contractor.	Medium	High	High
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, resettle beachfront businesses who pollute the sea.	Medium Low	High High	Very 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/seawater 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 High	Medium Medium High

Source: Data collected in the field.

35 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

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

37 See 'Flooding' section of the direct impacts table

Table 4: Secondary Climate Threats

Climate Risk	*Additional/Secondary Impact*	*Vulnerable Groups*	*Options for Adaptation*	*Urgency to act*
Increased Temperatures	Heat related diseases – Dehydration. Cardiovascular problems. Respiratory problems.	The young, the elderly, the sick, pregnant women.	Education/awareness raising Better access to clean drinking water.	Medium
	Increased requirement for cooling. Declining air quality.	The poor, local businesses, the local government. All, particularly the young, the old and those with pre-existing health conditions.	Better ventilation, possibly through building regulation and urban planning.	Medium
	Fish species migration[38].	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
Drought	Loss of/decline in agricultural production, leading to rising food prices[39].	The poorest, landless people, local restaurant businesses.	Climate resilient agriculture through better water management and infrastructure.	Low[40]
	Stress on fresh water supply and/or requirement to import water.	The poorest.	Better management of water, capture and storage[41] 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
	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 to city system[42].	High
Sea Level Rise	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

Source: Data collected in the field.

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

39 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

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

41 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.

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

6.0

Analysis and Recommendations

6.1 BUSINESS AS USUAL

Business as usual represents the likely impact of what would happen if no action is taken to adapt to climate change - that is if only autonomous and unplanned adaptation takes place. The cost of business as usual must then be derived from where sensitivity is highest and where adaptive capacity is lowest. Data gathered in the course of this report suggest that business as usual can be summarized in Table 5. (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*[43]
Sea Level Rise	Damage to homes.	Medium	High	Up to 2000 families affected, landlessness, forced resettlement, 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/dust.
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.
	Waterborne 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/dust.
	Damage to homes.	Medium	High	A significant number of families possibly affected, loss of livelihoods.

Source: Data collected in the field.

43 Costs here are considered to be economic, social and environmental

6.2 HIGH PRIORITY AREAS AND ISSUES

Tumnup Rolok[44] Rather than try to delineate the complex amalgam of challenges the Tumnup Rolok area currently faces, the report instead finds this location, in and of itself, to be a high priority target area. Due to the area's low-lying topography – and dense population, 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:

- Its proximity to the sea, and sub one-metre elevation
- The general vulnerability of fishery livelihoods to climate change, though poor quality fishing boats and impacts on fish populations
- Population density and lack of secure land tenure
- The lack of reliable weather and storm information available to local people, particularly fishermen
- 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
- Water supply and sanitation services

Therefore, the priority actions here are as follows: as part of the urban master plan process, a social land concession relocation site could be sought. This is a process which is already underway but a more holistic approach might include a more participatory process with key stakeholders, including the communities, using the "Circular 3" implementation mechanism. It is likely that there will be initial resistance from community members. Therefore, the Government should consider this a long-term (i.e. 30-year) strategy, moving either the most vulnerable or those wishing to leave first, or both. Climate change is not a justification for relocating the community at present, but it poses increasing risks to them in the long run. In the short term,improving basic services (water and sanitation, waste, healthcare and improved housing) represents the best adaptation option.

6.2.2 Governance and Service Provision Issues

Sewage, drainage, waste management and urban planning are all priority areas for the city. Effective management of each will increase resilience to climate change. Finalizing, approving and implementing the urban master plan should be a priority for the city. Cities without urban master plans are usually more vulnerable[45] to climate change and the master plan should be a vehicle through which Sihanoukville can achieve a vision for strategic urban development over a period of, say, 30 years.

An urban master plan, the provisions of which is developed and implemented with partnerships between stakeholders (including vulnerable communities) also offers the opportunity to discover synergies between adaptation and mitigation, which will become increasingly important in the long run as the city economy moves toward more polluting industries. The master plan 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 reduce climate vulnerability and the "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. Such infrastructure is potentially 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. However, it is likely to be far higher than the existing USD10 million estimated for improvements.

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

45 See, for example, Dodman, 2009

Sewage is also a high priority for the city and effective management of it is vital 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 situation. Given that nearly 70 per cent of families are unconnected to the city sewage system, linking them to the system should be a short-term priority, 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 master plan.

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; first, it should continue and scale up the advertising, awareness and education programmes about the harmful effects of littering and improper waste disposal, on behalf of individual households. Second, 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 should be studied further, citing successes in other cities. Third, a legal framework should be in place which punishes those who litter and fines companies if they fail to collect waste and provide better facilities for waste disposal (green garbage collection 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 throughout the local government, particularly on the technical aspects of climate change. Project implementation capacity was found to be good, due to the ongoing Partnership in Environmental Management for Seas of East Asia (also known as PEMSEA) initiative; and future UN-Habitat involvement in Sihanoukville should seek to work closely with PEMSEA, particularly in this regard. Community capacity, especially in the poorer areas of the city, is very low. Raising awareness of environmental issues, including behaviour which can help to mitigate risk and increase resilience, should be a priority. The Department of Environment and that of Public Works and Transport does some of this work and has had limited success. However,their actions should be 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. This is in line with national policy objectives.

6.2.3 Livelihoods and Ecosystem Services

Tourism in Sihanoukville is highly vulnerable to climate change due to its dependence on climate sensitive attractions – primarily its beaches, but also water sportsincluding 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 possible reductions in tourist numbers during the rainy season.

The loss of beach to sea level rise and erosion is a pressing concern. More research is needed on preventative measures in this area. One option for further study is either artificial extension of the beach or re-enforcement of the existing sand, or both. The costs of this may be prohibitive but it should be considered as an option and thus studied further, possibly as part of the master planning process. Governance issues, discussed 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. There is room to integrate this with continued monitoring of coral and seagrass 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 deal in 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.

7.0

Conclusion

Overall, Sihanoukville is vulnerable to climate change, which will present 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 existing problems. The priorities recommended here may seem quite general, but they are presented in such a way as to be designed to offset wider issues, rather than just climate change which should not, and cannot, be delineated. The priorities identified here are strategic, which, if acted upon, would enable the city to develop in a sustainable, climate-resilient way.

UN-Habitat is now working with the Preah Sihanouk Provincial government on small-scale pilot interventions in the areas of waste management, weather information, coastal protection and better service delivery. The aim of this collaboration is to reduce vulnerability to climate change. These initiatives are ongoing. After their completion, work would be need to ensure that reducing climate vulnerability is mainstreamed into the subnational planning and financing process. Subnational planning and financing ensures that there will be local government ownership of the response to climate change. If this can take place alongside the consistent capacity-building efforts which have been highlighted in this report, the overall vulnerability of the city could be reduced.

UN-Habitat's Cities and Climate Change Initiative supports local governments and communities in assessing their climate change vulnerabilities. These assessments lay the foundation for evidence based decision making and better urban planning. This series of abridged vulnerability assessment reports encourages local governments, civil society organizations - including representatives of the urban poor, the private sector and other urban stakeholders to engage in local climate change discussions. These documents are also a means for sharing climate change information between cities and to inspire local governments to take the first step in addressing climate change by presenting climate change assessments in an accessible format.

The vulnerability assessment of Sihanoukville, Cambodia, is the result of an in-depth national and local literature and data review, interviews and discussions with an extensive range of local government stakeholders and a community-focused participatory assessment. It considers existing vulnerabilities, municipal plans and priorities and assesses how climate change will affect these.

Initial recommendations focus on the integration of climate change into the coastal-urban master plan. In particular, improving basic services such as storm water drainage and solid waste management are priority areas. Early warning systems and disaster preparedness, coastal zone protection and livelihood strategies for the most vulnerable groups are other priorities.

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