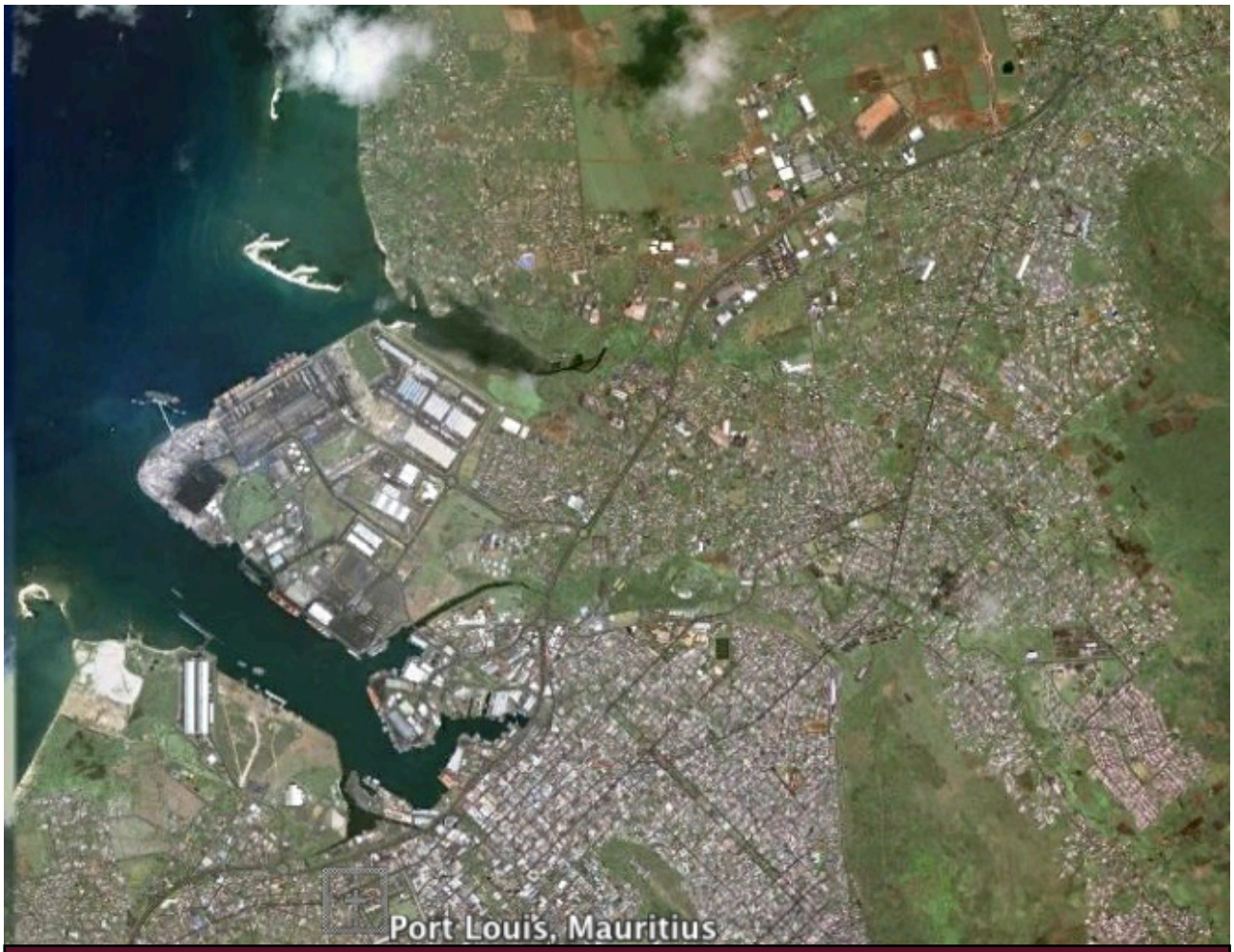
Building Climate Resilience

A Handbook for **Port Louis Municipal Council,** Mauritius



A Handbook for adaptation to climate change and increasing resilience for Port Louis, Mauritius

This Resilience Handbook is a key deliverable of the ICLEI-Africa Project Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action

I·C·L·E·I Local Governments for Sustainability

Adaptation IDRC CRDI DFID Department for International Development

ICLEI - Local Governments for Sustainability's mission is to build and serve a worldwide movement of local governments to achieve tangible improvements in global sustainability through cumulative local actions.

The **Climate Change Adaptation in Africa (CCAA)** program seeks to improve the ability of African countries to adapt to climate change in ways that benefit the most vulnerable.
Funded by the UK's Department for International Development, the program supports African researchers' efforts to help communities adapt to the effects of climate change.
Originally planned as a five-year initiative, the CCAA program was extended to March 31, 2012. The program has funded 46 research and capacity-building projects in 33 African countries. A wealth of new knowledge on adaptation is emerging and being shared with those who will most directly benefit. CCAA's support for climate change initiatives in Africa aims to help Africans create better, more informed adaptation policies and plans. Some of the results CCAA grantees are achieving can be found here (access to technical reports, research papers, policy briefs, and much more).

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Cover image: Google Earth. All other images from Vanessa Stephen unless otherwise stated.

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Foreword

Climate change is anticipated to have severe physical, social, environmental and economic impacts in cities worldwide. These are expected to be felt with greater intensity in the developing world, particularly Africa. There is strong evidence that a changing climate will affect people's access to, and the quality of, basic goods and services such as water, food and shelter, and that this will result in significant impacts on people's livelihoods. Local governments are faced with dealing with the challenges that these impacts bring in the face of normal day-to day developmental challenges. In the context of this Climate Change Resilience Handbook, the key goal of these African local governments is to reduce vulnerability and increase resilience to climatic change through pro-active planning and forward thinking, whilst considering the projected changes. In this instance, understanding the anticipated impacts, the bases of local livelihood asset security, is key for successfully meeting these challenges.

Adapting to a changing climate is therefore crucial in order to manage the risks and threats to people's livelihoods and local government infrastructure and service delivery. As a strategy to tackle this, adaptation is becoming increasingly recognised as vital for resilience to climate change induced impacts that are already being experienced across the world. There is a general consensus that scientific evidence is projecting that these impacts will increase in frequency and severity, and that urban local governments will experience these in ways that will exacerbate the developmental issues that they already face. Adaptation/ resilience strategies will therefore play a pivotal role in how local governments and communities are able to ensure continued and improved resilience to climate change impacts.

African cities in particular are faced with the two-fold challenge of managing climate change risk and simultaneously extending their services, providing housing and infrastructure, and ensuring that this development doesn't compromise the health and the environment of future generations. However,

> **"For cities that get this right, there is the potential to not only safeguard their assets and inhabitants, but to advance local development, competitiveness and to draw down some of the finance and donor support that is emerging for cities that are seen to be pro-active against climate change."** (Cartwright, 2012.)

Therefore, being at the forefront of managing climate change risk through the use and implementation of adaptation strategies will not only have short-term benefits, but is likely to furnish the cities' future with a competitive advantage over others if high levels of sustainability and socio-economic resilience is achieved and demonstrated.

This Handbook places its emphasis on three key concepts: **Interconnectivity, Continuity and Local Relevance**. The first one, interconnectivity, refers to how the different climatic impacts and the associated adaptation options are connected. Through addressing one particular impact or implementing one adaptation option, there are generally knock-on effects affecting a multitude of people, sectors and economies (the ripple effect). Essentially, no activity or event occurs in isolation, social, economic and ecological systems are connected, and it is imperative that we make the best use of the opportunities that come from this interconnectivity. **Just as climatic events and patterns are likely to keep changing, so must our responses!**

Adaptation is an ongoing process, which must be continuously monitored and evaluated for its appropriateness and effectiveness. Building resilience is not a 'once-off' effort, it is a way of moving forward that considers the dynamic environments and systems in which we operate. In order to ensure relevance and the use of this Handbook for Port Louis Municipal Council, it is important to consider the local context. By including local and recent examples of impacts of climatic events within the context of a changing climate, the links to everyday situations at the local level are made stronger. Although the concept of adaptation and resilience is rather universal and relatively new, it is the actual implementation that determines its success.

Recommendations

The city of Port Louis, and indeed the entire island of Mauritius is highly dependent upon the port for the secure import and export of goods and services, as it is the main link to the rest of the world. Due to the land space and natural resources available, as well as the isolated location within the Indian Ocean, Mauritius needs to import many goods ranging from fuel to food, and the predominantly textile and agricultural exports are necessary to enable a healthy Gross Domestic Product (GDP). With this is mind, it is essential that the functionality of the port is prioritised at the highest level with climate adaptation options keeping this functionality as a core goal to ensure the city's resilience to a changing climate.

The port faces a number of challenges associated with climate change, both in the short and the long term. These challenges range from short term and permanent inundation of salty sea water (sea storm surges and/or cyclones and mean sea-level rise), the introduction of invasive species (through trade but now able to survive in a new geographical region due to changing temperatures etc.), fresh water flash floods (resulting from extreme rainfall events occurring inland, the downpour of water travels to the areas of lower elevation carrying waste and other debris along with it). However, in combination with these climatic phenomena, there are many impacts coming from the local populace that, when combined with extreme climatic impacts, are often intensified through human activities such as the incorrect disposal of garbage which, during times of intense rainfall and flash floods gets carried into the lower lying areas, and in the case of Port Louis, is carried out to sea or through to the port, often resulting in the disruption of harbour activities and increasing the cost of clean up activities

Five rivers flow into the port and during peak rainfall events these rivers carry a great deal of debris into the harbour which accumulates and can damage vessels - particularly the propellors on tug boats and other port traffic. Whilst the first important steps of recognising the nature and the cause of the problem and initiating some actions (between the Mauritian Port Authority and the City of Port Louis) such as the development and installation of grid gates in order to capture the waste, it is acknowledged that the maintenance practices to accompany this initiative and thus ensure its success are, at times, not entirely effective. It has been noted, that there are times when the solid waste and debris accumulate at the grid gates, resulting in a damming effect, where the water backs up and can result in localised flooding around the vicinity of the gate locations. On occasion, the grid gates are then required to be opened in order to reduce the flooding risk, resulting in the debris and waste flowing into the port.

It is recommended that all local government departments focus on inter-departmental communications and work together to address the issues that can be avoided. The Port Louis Municipal Council has done well to identify and work to alleviate certain stresses, however better communication will go a long way to ensuring seamless functionality of the systems installed and overall lead to far greater resilience to climate change. It has been suggested, through the consultative processes undertaken as part of this project that perhaps, the development of a regular forum for the different key governmental departments (where some responsibilities and mandates overlap or run parallel to each other), could allow for an open and transparent manner of maintenance reporting and status updates in order that all stakeholders may be aware of such issues and thus take the necessary action on their part. As will be explained in more detail in this Handbook, interconnectivity is key. One impact may affect several departments therefore it is necessary that all sectors work together to achieve the desired outcomes.

"Similar to all island states, ports are critical links in the supply chain and to promote economic growth. In the past five years the port and maritime sectors have moved from a situation of boom and severe congestion to one of uncertainty and loss of business associated with the effects of the world economic crisis." (SIDS, 2010)

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1. Setting the scene - the project and its process

This Climate Resilience Handbook is a key deliverable developed during an ICLEI-Africa project entitled, *Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action*. The project has addressed the knowledge, resource, capacity and networking gaps through strengthening and facilitating the ability to plan for, and adapting to, impacts associated with climate change. This tailor-made resilience Handbook outlines locally specific actions that have been decided upon through a number of interactive consultative processes with key local stakeholders, for implementation to increase adaptive capacity at the local government level, through their stakeholder platforms. The aim has been to identify and prioritise appropriate and tangible local actions for enhancing the cities' resilience and adaptive capacity whilst increasing local level understanding of climate change and adaptation in order to enhance climate change considerations in decision making processes.

The project, managed by ICLEI-Africa, South Africa has been undertaken in partnership with five Sub-Saharan African local governments (Walvis Bay Municipality, Namibia; The City of Cape Town, South Africa; Maputo Municipal Council, Mozambique; Temeke Municipal Council, Dar es Salaam, Tanzania and Port Louis Municipal Council, Mauritius). ICLEI-Africa is mandated to work with local governments across all Sub-Saharan countries towards environmentally sustainable development. It is within these parameters that ICLEI-Africa has focused its attention on adaptation in these local governments. This project falls within a broader research context of the Climate Change Adaptation in Africa Programme, a jointly funded initiative by the International Development Research Council (IDRC) and the Department for International Development (DFID).

Each of the five local governments were selected as they are each rapidly growing, urban centres located on the African coastline, comprising of a broad range of urban socio-economic demographics. Each is considered to be a fast developing, coastal economic hub with harbour and is fundamental when considering national Gross Domestic Product (GDP). Each urban centre contributes significantly towards the understanding of climate change induced impacts on, and within coastal urban environments in developing countries, and demonstrates how local governments and communities can include climate change consideration in decision making processes towards the risks associated with a changing climate.

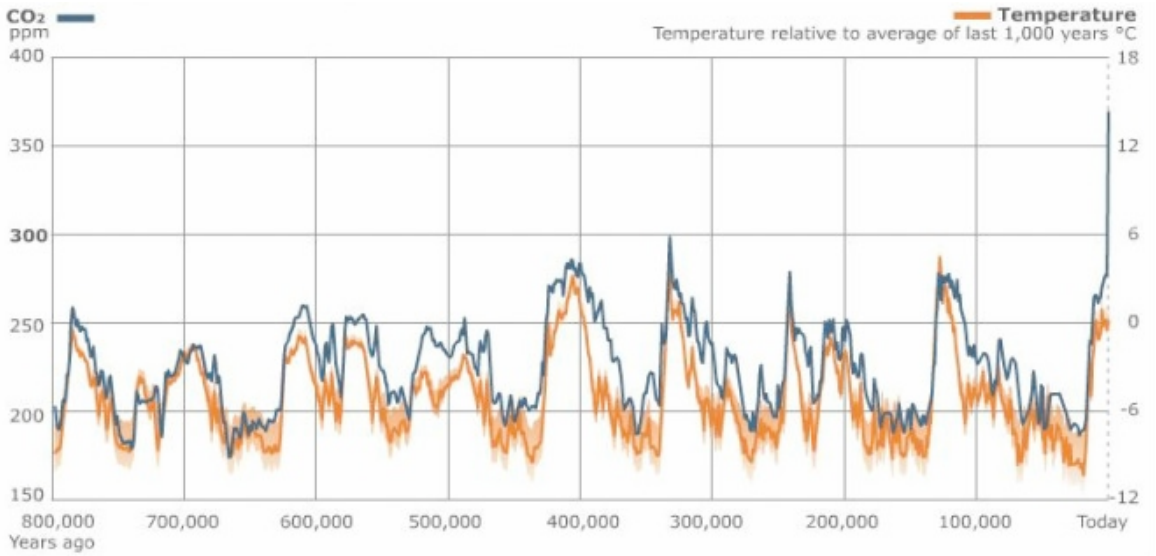
> **"A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events"** (SREX, 2012).

1.1 A brief look at climate change

Research into climate change has grown enormously over the past decade and while it remains an inexact science, there is a general consensus globally that the planet is warming, resulting in a number of other changes in the climate system and that this is attributable to human activities. A changing climate is a natural occurrence, however, the rate at which changes are projected to occur are happening faster than has ever, to our knowledge, happened in the past and will lead to enormous challenges to the human populace and the natural world. Human development since the 1800s has relied heavily on fossil fuels that has resulted in many millions of tons of CO_2 being released into the atmosphere. As can be seen in the British Antarctic Survey's figure of atmospheric CO_2 levels over the past 800 000 years, it is clear that a rise in CO_2 directly correlates with a rise in temperature. Due to human activity, the level of atmospheric CO_2 is now much higher than it has been at any time in the past and will continue to rise in the future as human development and industrial activity continues.

Temperature changes correlating to CO_2 increases happen over a slightly longer time period, what is known as a 'lag effect', however research has shown that we are now committed to a global rise in temperature of 2.2 °C. The IPCC 4th Assessment report (2007), states that this rise in temperature affects all weather systems leading to changes in precipitation patterns, wind speed and direction, ocean currents and sea level, each varying depending on the location on the earth. However, the special IPCC report, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX, 2012) states that climate change will manifest itself through extreme climatic events.

Whether they be storms, hurricanes, flash flooding or drought, these will become more intense in their severity, last longer and occur more frequently, throughout the globe. The challenges to countries and their governments, national and local will likewise become more intense. Adaptation to this changing climate will not be easy and will need constant reassessment, investment and new thinking, however the costs of doing nothing will be far more severe in the long term.



Data: British Antarctic Survey; Graph: BBC

While CO_2 emissions continue unabated, these projections will become ever more extreme so it is worth bearing in mind that a global rise in temperature of 2.2°C is not necessarily the worst case scenario, but may in fact end up to be several degrees higher. It is worth noting that each of the cities participating in this Five-City Adaptation Network have already noticed changes to their local climate.

1.2 About the Climate Resilience Handbook

This Climate Resilience Handbook draws upon a participatory, interactive, consultative process that has worked through the identification of climate related risks, impacts and adaptation options. It has been prioritised by the Port Louis Environmental Management Forum, a key Stakeholder Platform officially recognised by council, as part of the ICLEI-Africa Project *'Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action Project*'. It outlines a framework for action for enhancing adaptive capacity and building resilience within Port Louis' Municipal jurisdiction, in order for local key stakeholders to identify realistic timeframes, responsibilities and economic considerations associated with each step, and thus make the informed and well-considered locally appropriate decisions regarding the social, economic and ecological sustainability of the local government. Each Handbook contains examples of good practice that the city has done and can be used as a source of inspiration for other cities in the network.

> "At the local level there is traditional knowledge about disaster risk and grassroots actions to
> manage it. Functional or physical units such as watersheds, ecological zones, or economic regions operate at the local level, including the private and public institutions that govern their use and management." (SREX, 2012)

This Handbook briefly describes the context of the overarching Five-City Network Project and its findings, whilst focusing specifically on the Port Louis Municipal Council jurisdiction, providing an account of the projected changes in climate that are anticipated to compromise the municipality's basic services, functions and the livelihoods of various communities and public sectors that fall within the Port Louis Municipal jurisdiction. The main aim of the development of this Handbook is to assist the local authority and its key stakeholders in increasing adaptive capacity through the implementation of sustainable and smart solutions. It should be noted that **the Climate Resilience Handbook's success is dependent upon the commitment and follow-through of all key stakeholders**.

1.3 Who should use the Handbook?

This Handbook has been designed and developed over a three year period with a variety of key local stakeholders, undertaking a number of participatory processes aiming to provide guidance and steps for the implementation of actions towards enhancing resilience to climate change for Port Louis Municipal Council. It is targeted at local government officials, sustainability practitioners in the private and public sectors, and in particular those in the field of spatial planning and the built environment, whilst incorporating civil society organisations and decision-makers.

What is so special about this Resilience Handbook?

This Handbook represents a culmination processes that Port Louis Municipal Council and key stakeholders have undertaken in collaboration with ICLEI-Africa and the other local governments that partnered in the project, to create a platform for discussion and engagement around multi-level, inclusive and integrated adaptation solutions for increasing resilience to a changing climate. The contents of this Handbook are based upon rigorous research, relevant data from a wide range of sectors, and stakeholders in Port Louis Municipal Council in order to ensure wide and inclusive applicability to enhance implementation.

The knowledge-base of this project, and Handbook, has been built upon:

- Science – downscaled climate models, desktop research
- Documentation – workshops, photographic evidence
- Anecdotal information – peoples' real-life experiences and understanding
- Observations – by the ICLEI-Africa adaptation team, consultants and the stakeholders
- Participatory Action Research Tools – developed by ICLEI-Africa for use with the key local stakeholders to ensure inclusion of the locally specific needs and collaboration with the ICLEI-Africa team and the other pioneering local governments in the project

As such, the Handbook comprises a unique and wide representation of climate change impacts, its consequences and adaptation options for Port Louis Municipal Council.

Want to read for yourself?

All documents generated through the ICLEI-Africa Project *Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action*, are available for download on www.ResilientAfrica.org.

Here you will find the following documents for each participating city:

- The Sectoral Risk Baseline Studies
- Local level (for each participating local government) Climate Systems Reports
- The Resilience Handbooks
- Stakeholder Workshop reports
- Local Interactive Climate Change Risk and Adaptation Prioritisation Training Tool (RAP)
- Local interactive Climate Change and Climate Impact Training Tool (ICCCI)

You can also download:

- A Climate Risk Concept paper developed for this project
- A Regional Climate System Analysis report developed through the use of historical climate data and climate models providing projections on climate change over Southern Africa: Namibia, South Africa, Mozambique, Tanzania and Mauritius respectively.

Defining **resilience** within an urban context

Resilience is a system's (social, economic or ecological) capacity to adapt to external changes without losing its basic functions or ability to keep performing the same services within the changed environment.

Local environments are constantly fluctuating, but over time they become relatively stable with ecosystems and environmental services working in an equilibrium until there is some form of external disturbance exerting pressure on that environment. Disturbances are a natural part of all environments, and more broadly nature, taking place in the form of fire, drought, flooding and storms to name some examples. These and other disturbances in the environment drive plants, animals and people to adapt to those changes in order to ensure survival. That adaptation, and the ability to survive after such an event is the first of two factors of ecological resilience. The second is when a tipping point is reached and an ecosystem begins to fail due to increased, prolonged external pressures (such as pollution, development disturbances, loss of keystone species and changes in rainfall or temperature patterns) due to the fact that species within that environment are unable to adapt at a rate that equals the levels of disturbance and begin to decline.

For example, dams and reservoirs are essential to providing water to industries, communities and individuals. Algae will grow naturally in these dams and in the right quantities actually help to filter out impurities, thus improving the water quality. However, if the dam becomes polluted by, for example, fertiliser run-off, the added nutrients in the water will fuel algal growth (also known as an algal bloom). This can reach a point where there is too much growth and the plant matter starts to shade the areas underneath it. The shaded algae then die, creating more nutrients and fuelling the growth of bacteria that breaks it down. These bacteria use oxygen in their respiratory process and remove too much oxygen from the water and create an anoxic environment which then kills more algae. This cycle continues until a tipping point is reached where the ecological resilience of that ecosystem is compromised. The system can no longer cope with the changes and the water quality deteriorates so much that it cannot be used for public needs, such as consumption, without being treated, adding to expense. The stress of added costs puts pressure on the economic and other related system's resilience, as poor water quality poses health risks that can undermine the social system.

Resilience to a cause of impact can be difficult to measure, and while ecosystems in general are relatively tough, if a tipping point is reached causing a system to go into decline and lose its functionality, it can be very difficult to rectify and may take many years with huge financial costs. In the face of climate change this is an increasing worry. Climate change models and projections agree that average global temperatures will increase in the future and rainfall patterns will change, resulting in some regions getting more rain, and others less. As temperature and water are driving forces in ecosystem functionality, we need to consider the worst-case scenarios in order to attempt to remove as many environmental stresses as possible in efforts to make our ecosystems resilient to these projected changes.

Ensuring ecological resilience is necessary not only in terms of conservation but for human safety and security as we make use of numerous ecosystem services and that which they provide, such as clean drinking water, building materials (wood, thatch) and food. Without effective adaptation and increasing ecological resilience, we are likely to lose these services to our cost.

1.4 Suggested sources of information

Although this Climate Resilience Handbook is a stand-alone document, users are recommended to read other documents and reports that have been developed through the undertaking of research, peer review and consultative participatory processes.

Port Louis key stakeholders and decision makers can also benefit from reading the reports developed through project processes undertaken with other participating cities, whilst also taking their success stories, challenges and lessons learned into account continuously so as to avoid undertaking adaptation options that may not result in increasing climate change resilience. ICLEI-Africa further recommends that the leaders of the project (both political and technical), and participating local governments, (Walvis Bay Municipality, Namibia; The City of Cape Town, South Africa; Maputo Municipal Council, Mozambique; Temeke Municipal Council, Dar es Salaam, Tanzania and Port Louis Municipal Council, Mauritius) continue to communicate with each other, building on the network that has already been created throughout the implementation of project adaptation processes, and that they each also communicate with other cities and local governments in the ICLEI Global Network.

2. Adaptation: The road to increasing climate resilience

Port Louis' floating debris collecting craft, modeled on a similar craft seen in Cape Town's harbour, is a good example of how cities can learn good practice from each other. Collecting rubbish that has entered the port along river margins, reduces damage to propellors and creates an overall healthier marine environment.

One aspect of adaptation is the process of preparing communities for the impacts associated with climate change. It is acknowledged that climate projections are to some extent, an uncertain science. As with all development issues, the key to effective adaptation is to ensure that communities have an understanding and the capacity to deal with unforeseen changes and impacts.

Effective adaptation also needs to be strategic, and measures chosen need to be well-founded and based upon on existing local conditions and contexts. The processes undertaken in the development of this document are the first important steps towards strategic adaptation planning and effective implementation.

Adaptation measures at the local government level can be focused around five main areas to ensure successful implementation:

1. Enhancing the adaptive capacity of local decision-makers, planners and other stakeholders.
2. Mainstreaming adaptation into existing policies, plans and day-to-day operations of local government.
3. Understanding the socio-economic impacts of climate change, with particular concern for vulnerable communities.
4. Promote and improve cooperation between stakeholders on multiple levels and ensuring that all aspects have been considered.
5. Understanding the full concept of climate related risk so as to assist in the prioritisation of climate action.

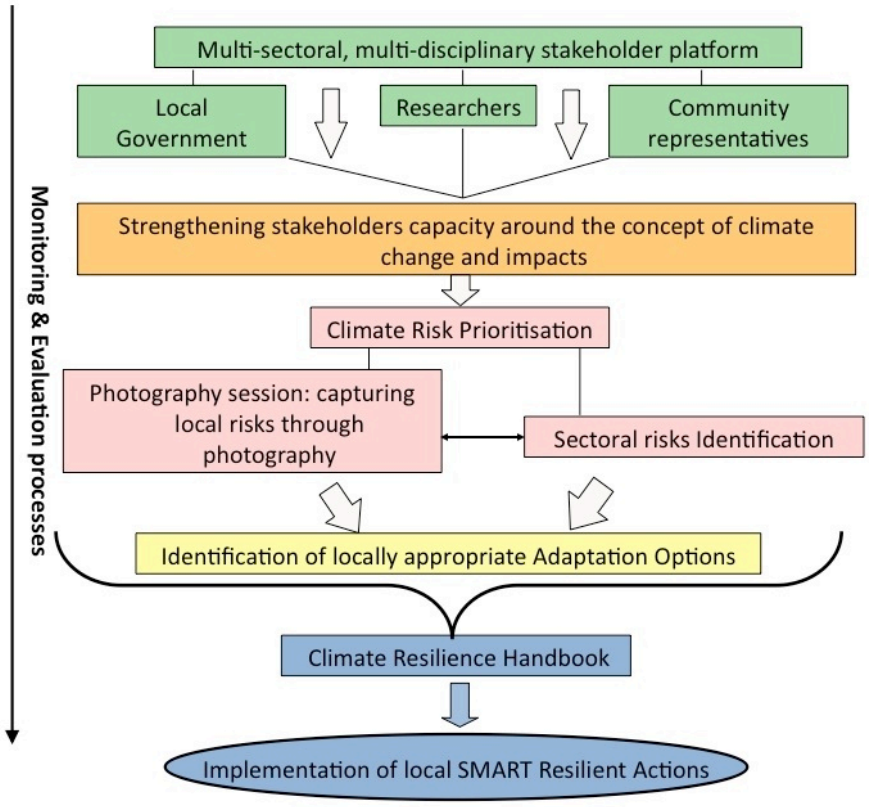


Figure 2.1 Illustrated step by step process undertaken within the timeframe of this project to enhance and improve climate adaptation and thereby increase climate resilience.

Each participating local government has completed the steps outlined in Figure 2.1 whilst developing, in a participatory manner this Climate Resilience Handbook. All steps are well-documented in supporting literature and are referred to within this Handbook. The next step required to enhance adaptation to climate change within Port Louis Municipal Council is to anchor this Handbook within the relevant government structures, (local, regional governments), to assist with securing its implementation and inclusion in the government processes, and to start implementing the identified adaptation options.

Interconnectivity, continuity and local relevance

Everything in this world is connected. Building resilience means considering how social, economic and ecological systems – the three pillars of sustainable development – are interconnected. The human world is dependent upon the natural world, and human activities inevitably impact upon the world's ecosystems. Major changes in one of the systems will therefore have some sort of effect on the other. This is also true at the local level. Prolonged dry-spells in Port Louis has consequences for local economic activities, such as agriculture, and also for municipal services, such as water supply. The reduced availability of water will lead to a decline in agricultural output, as the crops need water. It also means less water for human consumption and use, whether it is for drinking, washing or sewerage systems. The knock-on effects are many and spread over a range of sectors: Fewer tons of sugar cane means less income, compromised access to potable water and water for sewerage systems have negative health effects, such as increased risk for water-borne diseases and dehydration. Failing sewerage systems will contaminate local ecosystems such as fish habitats, which are valuable sources of income for local people. Any measure to tackle the consequences of prolonged dry-spells should therefore consider the cross-sectoral impacts, and the ***interconnectivity*** of systems and events. This will also make it easier to identify opportunities and to reduce risk.

Due to the ever-changing nature of the urban environment, adaptation should be a way of doing things and not an add-on to the to-do list, or an afterthought. It requires changing the way of thinking, planning and acting. Adaptation will therefore never be a complete process. It requires constant monitoring and evaluation in order to ensure effectiveness and appropriateness. Adapting continuously and planning for a wide range of scenarios, to avoid maladaptation, will thereby increase resilience to climate change. Whether it involves staff capacity-building, technical innovations or legislative frameworks, it is essential to bear in mind that the higher adaptive capacity these measures have, the better able they will be at dealing with the unforeseen. The concept of ***continuity*** hence applies to all aspects of an effective adaptation process: Planning, implementation and monitoring and evaluation.

Since there is no blue-print for 'correct' adaptation, especially at the local level, ***local relevance*** is what gives an adaptation strategy or an action plan its edge. Local knowledge, data and social networks are essential for the success of any adaptation measure and for building resilience at the local level. Plans for adaptation therefore need to be developed where they will be implemented, as no two areas are the same, influenced by exactly the same scenarios. Local governments all have different spatial plans, land use practices, social demographics, governance structures, infrastructure and service delivery, while also being embedded in their unique histories and heritages. To ensure relevant and effective adaptation measures, all of these factors need to be considered for them to be locally relevant, keeping the understanding and implementation of all actions undertaken at the same level.

Figure 2.2. The five milestones to climate resilience following the identification of a local government champion.

Increasing resilience to a changing climate is an ongoing process. As we cannot know all that may change, it is important to re-evaluate and acknowledge where the weaknesses and strengths are whilst keeping all stakeholders informed.

3. Projected changes in climate for Africa

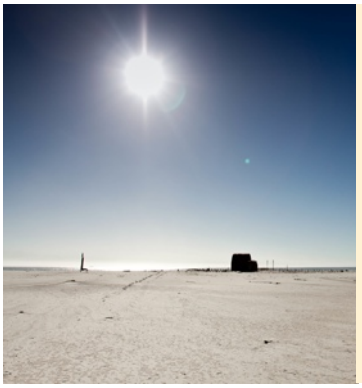
Below follows a brief summary of the projected climatic changes for Africa, Mauritius and Port Louis. More detailed information can be found in the Climate System Analysis Reports for Southern Africa and the downscaled climate change report for Port Louis.

Although there are some uncertainties surrounding the understanding of Earth's complex systems, there is strong evidence in current literature and climatic measurements to demonstrate that, as a result of increasing green house gas emissions, atmospheric and sea surface temperatures are rising. As a result we can expect impacts on our environmental, social and economic systems. In some cases these impacts are anticipated to have severe consequences for people's livelihoods as well as governments' ability to maintain basic service delivery, as is the case for Southern Africa.

Due to increasing atmospheric and sea surface temperatures we can expect a number of climatic changes that will impact globally upon the Earth's social-ecological systems:

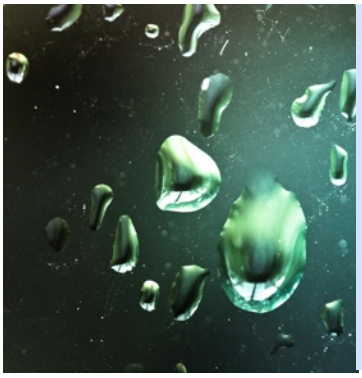
- Changes in rainfall and precipitation patterns (flooding and drought),
- Increases in temperature,
- Increasing frequency and intensity of storm surges or extreme events,
- Increasing average global sea levels due to melting glaciers and thermal expansion, and
- Changes in wind speed and direction.

Although Africa is a continent with abundant natural resources it remains the most underdeveloped continent globally. Development is slowed by extreme poverty, poor access to water, sanitation and health services, and inadequate food supplies (Sandbrook, 1985). Such 'multiple stresses', including limited access to capital, complex governance and institutional dimensions, and ecosystem degradation, make the continent particularly vulnerable to the impacts of climate change (IPCC 2007). Its one billion people will unfortunately bear the burden of a three-fold population-based risk of suffering adverse effects of climate change compared to the global total. As stated in the Stern Review (2006), the consequences of a changing climate will be most severe and widespread among the Sub-Saharan African population, and issues of water scarcity, health and malnutrition are likely to be exacerbated.



Temperature:

- A rise in temperature of between 1°C and 3°C is anticipated by 2050,
- Increases in warm spells over Western and Southern Africa has been observed,
- The number of extreme cold days are declining,
- Mean sea surface temperatures are anticipated to increase between 1.5°C and 6°C by 2100, and
- The warming trend is likely to change precipitation patterns.



Rainfall and precipitation:

- A 10 - 20% decline in rainfall is anticipated by 2070,
- River water-levels may fall by 50% by 2030 in various parts of Africa, and
- Climate change projections indicate that 230 million Africans will experience water scarcity by 2025 as a result of declining water resources and increasing constraints on water resources.

Frequency and intensity of severe weather:

- Over the next 50 years extreme weather events are anticipated to increase in frequency and intensity on the African continent,
- Tropical cyclones (typhoons and hurricanes) will likely become more intense with larger peak wind speeds and heavier precipitation, and
- There are strong indications that paths, intensity and frequency of strong storm and wave events will be affected by climate change leading to extreme rainfall events.

3.1 Climate change projections for Mauritius and Port Louis Municipal Council

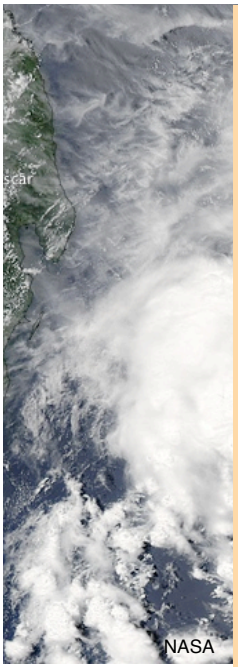
In the IPCC 4th Assessment report (2007), small islands are described as being highly vulnerable to climatic change. Port Louis, located on the north-western coastal zone of Mauritius, is exposed to high intensity storms associated with cyclones and sea storm surges originating in the warm Pacific Ocean. These storms are known to produce sea storm surges, flooding, coastal erosion and direct and indirect damage to infrastructure, services and property.

The increase in storm activity and severity is likely to be the most visible impact and the first to be noticed for Mauritius. Storm formations over the last three decades years show an increasing trend in the number of storms reaching tropical cyclone strength, and observations during the last decade indicate rapid and sometimes explosive intensification of tropical storms.

Port Louis, is frequently exposed to high intensity storms associated with tropical cyclones originating in the Pacific Ocean. The city and the port often experience sea-storm surges, flooding and coastal erosion, which damage infrastructure and property, and also compromise service-delivery and economic productivity.

The following climate change impacts have been projected for Port Louis:

Increased frequency and intensity of tropical cyclones: Due to its vulnerable location, Port Louis has had a lot of experience with tropical cyclones and has hence developed well-functioning systems to manage such events. The city will however need to plan for the increased severity of tropical cyclones and the added pressures this will put on livelihoods, infrastructure and service delivery, and the port in particular. While there has been a trend in the past decade for tropical cyclones in the area to develop and move further north of the island of Mauritius, the likelihood remains high that severe tropical cyclones will descend on the landmass.



Climate change projections for Mauritius include:

- The mean annual land temperature is projected to increase by 1.0 to 2.0°C by the 2060s, and 1.1 to 3.4°C by the 2090s,
- The sea surface temperature is anticipated to increase by between 0.51 to 3.77°C by 2100, and
- The sea level is estimated to rise by between 18cm and 59cm by 2100.

As a result, rainfall is anticipated to decrease, flash flood risks to increase, there will likely be more frequent heat waves, and increases in the number of intense tropical cyclones are also anticipated.

Impacts of cyclonic winds are likely to include:

- Impacts on and damage to coastal habitats, for example coral reefs,
- Damage to coastal infrastructure such as port infrastructure,
- Increased salt water intrusion and raised groundwater along the coast,
- Loss of coastal wetlands resulting from saltwater intrusion, erosion and landslides, and
- Potential tourism decline resulting from loss of beaches, coral reefs and coastal infrastructure.

Sea-level rise: A number of impacts are associated with increases in mean sea-level. Port Louis can expect intensified storm surges following tropical cyclones, which will exacerbate the impacts on coastal areas. Aside from consequences following extreme events, the city and the port are likely to experience saltwater intrusion and groundwater along the coast. This can damage infrastructure (rusting, erosion) raise the groundwater level (erosion) and change the biophysical environment in coastal wetlands due to saline inundation. It will also have a direct impact on the availability of freshwater for the populace as much of the potable water is drawn from aquifers.

Increased wind speeds: Gale force winds can easily damage telecommunication, disrupt transport routes (fallen trees) and damage houses. High wind speeds also makes it difficult for ships to make port, jeopardising a number of vital activities.

Flooding and flash floods: An increased mean sea-level means aggravated flooding during extreme events (storm surges) in addition to the heavy rain that follows tropical cyclones. Flooding is therefore expected to occur more frequently and intensely. More frequent flash flood events are already being experienced.

Drought: Reduced average rainfall and temperature increases have been projected for Port Louis and have already been experienced. The long-term projections indicate longer dry periods with increased temperatures broken by shorter periods of more intense rainfall. These dry periods will reduce water availability during periods of increased demand.

During the cyclone Hollanda in 1994, Mauritius experienced wind speeds of 225kmph followed by torrential rain. Port Louis suffered major infrastructural damaged and two deaths were reported. In addition to this, the sugar cane harvest dropped by 30% due to crop damages, other crops as well as indigenous vegetation also suffered damages. This compromised food security and local ecosystems. In addition 50% of telecommunications were severed, roads were blocked by fallen trees and landslides and 300 houses were destroyed and a further 160 severely damaged. When taking the costs of rehabilitation, production and income losses and crop damage into account, the total cost of the damage was estimated at US$84 million. Cyclone Hollanda's consequences exemplify how the combination of climatic variables (wind speed, rain, storm surge) has significant negative impacts across a range of sectors (transport, communication, health and livelihoods, food security and industrial productivity). Although Port Louis already has a sophisticated early warning system in place, the Municipal Council should increase the preparedness for more frequent and intense cyclones, and adapt to scenarios that also consider the effects of subtler climate change impacts. For example, a general reduction of fresh water, due to salt water intrusion damaging water infrastructure or longer dry-spells, will make the water supply system more vulnerable to the impacts of a tropical cyclone.

Using the sun and wind for energy

Energy is a sector always at risk from extreme climatic events. Downpours can cause rolling blackouts, and intense winds can break electricity wires (generally from trees or branches falling on them). The import of coal or fuel oil can also be delayed leading to insecurity in energy supply. Restoring interrupted electricity is a costly and time consuming exercise and the loss of energy can lead to a loss in income, potential health risks through spoiled food and the inability to boil suspect water for consumption, and disruption to industry.

The country is experienced in reconnecting disrupted energy with priority given to the capital city, however improvements can always be made. Port Louis gets its energy from a combination of different sources, which include gas, bagasse (a byproduct of sugar cane, which is converted into biofuel), and hydroelectricity. However the main source of energy remains the burning of coal and heavy fuel oil, which is imported and transported from the port to the power stations and contributes 58% of the island's total carbon emissions (CSO – Digest of Energy and Water Statistics, 2009). Port Louis has a vision to become the first zero carbon city in Africa and the Municipal Council is leading the way by making extensive use of solar energy capture, harvesting the 2900 hours of annual sunshine. An investment of Rs.10m has converted the Municipal Council buildings to run entirely on solar energy generated through a network of photovoltaic panels installed on the building's roof. These generate enough power to cover the building's every energy requirement, including the running of energy-intensive air-conditioning units and after a period of only five years will save Rs.1.9m per year.

The Municipal Council is in the process of converting many streetlights to run on solar power as well, and the island has implemented an incentive scheme for residents to install solar water heaters in their homes through the Maurice Ile Durable (MID) concept. Rs.10 000 grants are given to each household that installs a solar water system and so far 30 000 households have taken advantage of this grant. The MID projects, which aim to promote renewable resource use gathers their funds through levies on fuel. Currently a fee of 30cents/L on petroleum products, 30c/kg of coal and 30c/kg on LPG has covered the cost of this and other initiatives and continues to finance future initiatives.

There are additional plans in place to construct wind turbines on Mauritius to add more renewable energy to the grid following a successful trial on the island of Rodrigues. As tropical cyclones are projected to occur with more intensity and frequency in the changing climate, the potential for damage to the turbines through these storms has been taken into account and each turbine has the ability to be tilted to ground level during cyclonic events in order to minimise damage. The fact that Mauritius and Port Louis are looking at long-term solutions and are willing to initially invest large sums of money in order to see greater returns in the future, indicates that the city and island are committed to becoming resilient to the changing climate.

The port in focus

Port cities in general are pivotal for trade and development in the developing world. Increasing populations and wealth means growing demands on goods and services, for export as well as import. For small island states, their ports' ability to function in rapidly changing socio-ecological systems and an uncertain economic climate will be key for achieving sustainability and resilience.

Mauritius' main port, located just outside Port Louis, is depended upon by the majority of import and export trade. After a period of unprecedented growth in shipment traffic during 2005 – 2009, as a result of agreements with major shipping consortiums to use the port as a trans-shipment hub, the port's key role in the economy of Mauritius and Port Louis was even further entrenched (NAR, 2010). This became evident in the aftermath of the global economic crisis, where decreases in global trade have significantly reduced the activities in the port.

With climate change impacts expected to effect the port's functions, the pressure on port infrastructure and other services will intensify and add to the challenges of maintaining productivity to ensure a competitive advantage on an already marginalised market.

The greatest climate threat to the functionality of the port is damage caused by tropical cyclones and sea storm surges. Their frequency and severity are projected to increase leading to potential damage through increased rainfall and storm surges from the ocean. The ports authority has installed wave gates along the outer edge of the harbour to prevent big waves associated with sea storm surges from entering too far into the important port areas and causing damage to shipping containers, imported goods or those for export as well as protecting the existing infrastructure. These gates are closed once a Level 3 cyclone warning has been issued, which is also a signal for every vessel to leave the harbour. Such measures are considered to be cost effective and they require relatively little financial investment relative to the potential damage and risks associated from extreme climate events, yet they are highly effective in minimising the damage to the port from such cyclonic events.

3.2 Governance tools and institutions relevant for adaptation to climate change

Climate change adaptation frameworks and strategies for local governments should be situated within the context of other locally relevant governance tools. Identifying synergies and win-win situations between these different tools, sectors and departments is part of building long-term resilience to climate change and its associated impacts, whilst enhancing existing capacities and efficiency. It also helps reduce the risk of unnecessary misallocation of often-limited resources through repetition and duplication.

The development of Port Louis Municipal Council's climate impacts and Sectoral Risks Baseline Study included a thorough assessment of existing strategies and policies relevant for managing sustainability and building resilience for Mauritius and Port Louis. Some of the national key tools and institutions identified are:

- Mauritius was the first country to sign The United Nations Framework Convention on Climate Change (UNFCCC) and later acceded to the Kyoto Protocol.
- The National Environment Policy (NEP) of 2007 has a clear policy framework with environmental objectives and strategies and key priorities for the national context.
- The 'Maurice Ile Durable' Project promotes the concept of a sustainable island, and has made significant contributions towards the integration of climate change into private and public sector development strategies.
- The Africa Adaptation Programme (AAP) aims to mainstream climate change into Mauritius' institutional framework, policies and strategies.

There is currently little documentation in terms of specific local government policies and strategies for managing sustainability issues in Port Louis. This may be due to the level of decentralisation, but the authors of this Handbook are encouraged to know that the recently passed local government act in Mauritius is likely to change this, ensuring that the processes of decision making are carried out in a consultative, participatory and transparent fashion, thereby enabling and encouraging open and inclusive decision making at the local government level. Additionally, there is strong political will to further enhance the existing policies in order to develop resilience to adverse impacts of climate change and to ensure the achievement of sustainable development goals within Mauritius' structures and laws.

The gradual drying of the island of Mauritius and Port Louis

Historically, Port Louis has had ample rainfall and excellent quality rain-fed aquifers to supply the population with potable water, the distribution and maintenance of which is managed by the Central Water Authority of Mauritius (CWA). However, the changing climate is starting to affect rainfall patterns and the island is experiencing longer dry periods with warmer temperatures, interspersed with more intense, but shorter periods of rainfall. Annual rainfall has decreased over the period 1960-2006, at an average rate of 7.7 mm per month (8.7%) per decade and temperatures have increased by 0.74 – 1.2°C when compared to the 1961-1990 long term mean (McSweeney et al. 2008). Key stakeholders in the Energy and Public Utilities department have stated that the rainy period, which used to start in December is now more likely to occur in late February or early March and that these long periods without significant precipitation have led to the dams decreasing in volume by 80%. When rain does fall, most is lost to the ocean as the topography and hydro-geological condition of Mauritius does not facilitate maximum rainwater collection.

As much of Mauritius' GDP is gained through sugar cane agriculture, more than half (53%) of the island's water demands go to the cane industry. However, sugar cane is highly sensitive to climatic variations – particularly extreme events. Higher temperatures and a drying, warming climate will result in increased evapotranspiration and an increased demand for water supplies thereby increasing pressure on the already limited resources, whilst the population's needs simultaneously increase.

The city of Port Louis is raising awareness on the issue of drought and is offering a public incentive scheme to families to install rainwater tanks. Every family with a combined monthly income of a maximum of Rs.12000 is eligible to receive Rs.4000 towards a rainwater tank for their homes. The CWA is also promoting best practice water usage for agriculture throughout the island. As the climate is projected to continue to change in the coming years, the commitment shown to conserving water at this stage will help enormously in the city of Port Louis and indeed, the entire island's resilience to a dryer and warmer climate.

4. Risks for Port Louis Municipal Council

Through a series of interactive stakeholder workshops in Port Louis, the key local stakeholders have identified which climatic variables, their projected changes, sectoral risks and adaptation options are anticipated to have the most significant impact on the municipality's climate resilience.

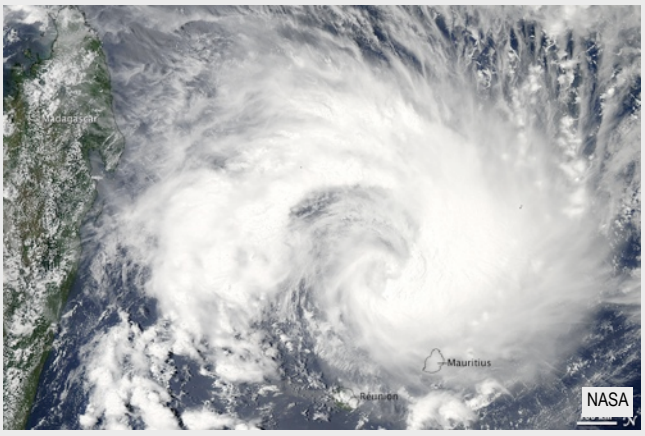
T**he key local stakeholders identified wind speed as the climate change variable exerting the most pressure upon service-delivery, infrastructure and local communities.** This would take effect in the form of tropical cyclones which also lead to flash flooding through the associated rainfall and sea storm surges. However, another climatic variable coming to the fore is drought. The island of Mauritius is experiencing longer dry periods interspersed with shorter, more intense rainfall events and stresses on the fresh water supply are becoming evident. Climate resilience plans therefore need to consider a number of climate variables and their combined impacts.

Key local stakeholders identifying and prioritising climate risks during the consultative process. (Images: ICLEI-Africa)

The triple risk of tropical cyclones

The force and speed of the wind is the first thing that comes to mind when assessing risks associated with tropical cyclones. However, the storm surge and torrential rain that follow cause much of the damage and even causalities associated with tropical cyclones.

Although there is consensus that the climate is warming, it has proven difficult to determine if, and if so how, the characteristics of tropical cyclones will change as a result. Two basic factors are responsible for intensification of tropical cyclones: Sea surface temperature and the moisture content of the environment of the storm, both of which have been observed and projected to increase significantly with the warming climate. For Mauritius, recent data indicates an increased number of storms reaching tropical cyclone strength, as well as a rapid intensification thereof.



The anticipated increase in mean sea level will exacerbate the impacts of tropical cyclones, meaning that the risk scenario for e.g. damage on coastal infrastructure, people's health and livelihoods, coastal tourism and other income-generating coastal activities will also increase.

The risk associated with tropical cyclones is therefore triple: Wind, rain and sea-level rise combined need to be considered for developing and implementing adaptation measures and building resilience, bearing in mind the likely scenario that all three variables will be exacerbated as a result of global warming.

4.1 Reasoning with risks

Climate 'risk' as a concept should be viewed in a holistic manner to consider the impacts of climate change over a range of sectors and disciplines, thus ensuring collective thinking and enabling the required multi-disciplinary approach to take this multi-faceted risk. It is imperative that the planning and implementation of actions to minimise climate risk sustains a holistic approach, in order to choose the most locally appropriate action. **A comprehensive risk analysis should consider the environmental, institutional, political, social and economic/ financial spheres for each impact and their chosen actions.**

As stated in the Climate Risk Concept paper (Cartwright, 2012), a stand-alone project publication to build capacity of key stakeholders and decision makers at the local government level, risk refers to the probability of a climate-related event occurring, multiplied by the cost to people and the things they value. Although risk is a part of everyday life, most people are averse to it and consider risk reduction necessary. In terms of risks associated with climate change, it is important to understand and acknowledge that determining the probability and ways in that such risks will have an impact is difficult. This is because climate change risk is:

- Peculiar: It is difficult to grasp and relate to (abstract concepts)
- Of an unprecedented nature: A global phenomenon caused by the accumulation of individual actions, accompanied by high levels of uncertainty
- As a result of the two, it is potentially damaging, and especially to areas and countries already faced with significant social, environmental and economic challenges.

It is imperative that local governments and the key stakeholders adequately understand the concept of climate change risk, as this forms part of the foundation for making appropriate and realistic decisions for adaptation (Cartwright, 2012).

Coral reefs and ecosystem services

The importance of coral reefs as ecosystems and habitats has long been known to the world. They provide humans with numerous valuable direct and indirect benefits. For Port Louis, its coral reefs are a major tourist attraction, and are hence important for the tourism industry. Coral reefs also provide a habitat and nursery grounds for a host of important fishery species and they act as a buffer against storm surges. Such benefits are called *ecosystem services* as the natural system of coral reefs supports various human economic activities (tourism), and mitigates potential damaging impacts on human-made infrastructure (storm surges). If the coral reef is damaged or lost, so too are the ecosystem services.

Image: Hagai Nativ, Wikimedia commons

The coral reefs outside Port Louis are under threat due to climatic impacts such as warming sea temperatures and ocean acidification (changing the biophysical conditions of the reef) and a general 'increased storminess' which may impact on the reefs and their inhabitants. It therefore becomes pivotal that the negative impacts generated by human activities are minimised in order to increase the reefs' resilience to the changing climate. Currently the reefs are suffering damage due to hazardous runoff from industries located in the coastal areas of Port Louis, as well as siltation from rivers carrying excess debris. The lack of a sewerage system poses another threat as untreated liquid waste is pumped straight into the sea. Liquid and solid waste from households (some people simply place their waste out in the street when it rains for it to wash away), constructions sites and cultivated areas (fertiliser, pesticides etc.) often end up on the coast, the port and the sea during heavy rains, which not only harms the corals, but also causes damage to vessels in the port, pollutes groundwater aquifers, and ruins the visual impact of the coastal areas, hence threatening the port's economic activities and the tourism industry.

4.2 Climate-related risks to service sectors

Through a consultative and participatory process, combined with scientific research, (i.e. documented impacts and effects, local anecdotal information and service provider experiences), key stakeholders from within Port Louis Municipal Council have identified the prioritised climate-related risks per service sector. Interactive engagement processes resulted in the effective prioritisation of climate-related risks pertaining to local service sectors. The most prioritised risks are outlined below (a complete list of the identified risks can be viewed in Annex 1).

Water and sanitation	**Livelihood impact**
Pollution and mud contaminants	Inadequate water supply
Damage to water supply infrastructure	Blockages and siltation of dams and water supply
Dams and fresh water supplies	Infrastructure and reduced freshwater availability
Increased storm surge events	Increased maintenance, reduced water availability and quality
Damage to coastal infrastructure	Compromised port productivity
Transport	
Damage to port infrastructure	Loss of days at sea, reduced port activity
Damage to and blockage of road infrastructure	Compromised imports and exports
Increased frequency of accidents, diversions and delays	Limited access, increase in delays, risk to public safety, loss of work hours
	Reduced transport accessibility for business and industry
Health	
Damage to clinics and other health infrastructure services	Increasing deaths and casualties and increases in pressure on medical services (causing a backlog)
Disruption of service delivery such as waste management & water supply	Increase in waterborne diseases and infectious diseases
Energy	
Damage and loss to energy production facilities and infrastructure	Disruption to work and businesses, dangers to public safety (loose cables, pressurised medical services)
Power outages; reduction in energy availability and production	Compromised service delivery and quality of life

Table 4.2.1. Prioritised risks and impacts relating to climate change for Port Louis Municipal Council.

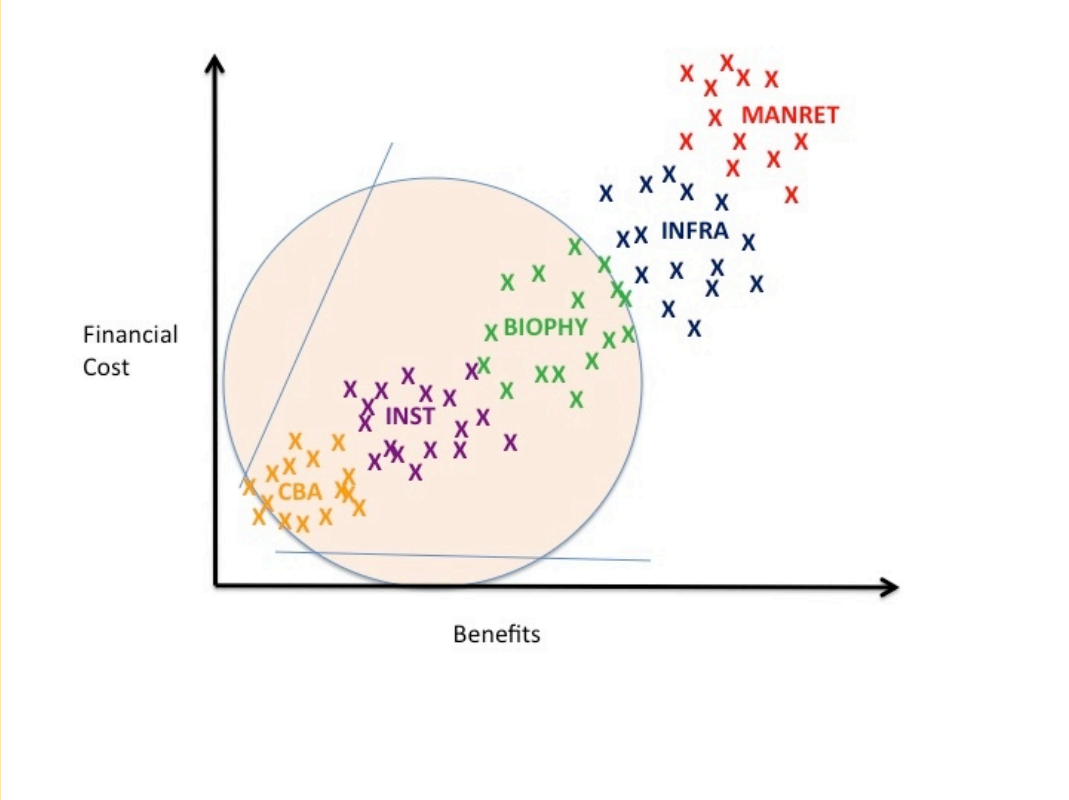
For choosing and implementing appropriate adaptation options, these risks and their impacts must be considered in order to ensure that the adaptation strategy is holistic and that it accounts for all levels of society. Risk management is also pivotal when considering the interconnectivity between different systems, events and actions.

5. Locally identified adaptation options

This section of the Climate Resilience Handbook presents the adaptation options which have been identified and prioritised for implementation by the Port Louis key local stakeholders. These have been chosen from the adaptation options identified in the third stakeholder workshop, and subsequently categorised according to the climate SMART Goal template (see Annex 2 for a complete list of the identified adaptation options).

There are five separate categories which encompasses the range of expenditure and effort required to implement each adaptation option. They are:

- Community based adaptation options (CBA i.e. community owned actions)
- Institutional adaptation options (INST. i.e. institutional arrangements and governance practices)
- Biophysical adaptation options (BIOPHY. i.e. the use of natural, soft and ecosystemic measures)
- Infrastructural adaptation options (INFRA.)
- And finally, preparing a managed retreat (MANRET.)



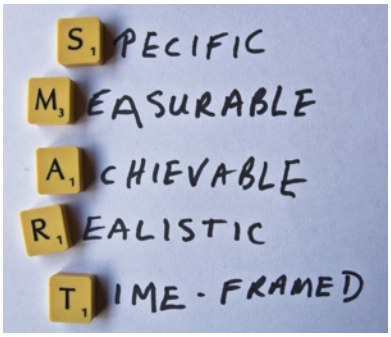
It is generally accepted that the infrastructural options require a great deal more in terms of logistics, financial expenditure, implementation and maintenance, although they deliver great benefits. If higher-end infrastructural adaptation options are undertaken, there may be little or no room for the inclusion/ undertaking of the community, institutional and biophysical options and whilst their benefits are great, their implementation costs are also high. Conversely, community, institutional and biophysical options can all be undertaken at the same time providing benefits across the board for a potentially lower total cost.

From the adaptation options selected during stakeholder workshops, these were organised in a manner that addressed all the identified and prioritised risks whilst keeping an emphasis on interconnectivity and local relevance for Port Louis. They address both climatic variables – high winds and flash floods from tropical cyclones as well as drought from longer periods between rainfall events and will form the climate SMART Goals for Port Louis Municipal Council.
These options are not exclusive of the implementation of additional climate adaptation goals.

These local adaptation options (listed in Annex 2) have been entered into the online tool developed by ICLEI-Africa specifically for this project, in order to prioritise and refine your SMART Goals. The Port Louis Municipal Council now needs to finish this online process by determining specific deliverables, actions, outputs responsibilities and timeframes in order to receive a report delivering the SMART Goal reports crafted to your local specifications and situation.

6. SMART Goals

SMART stands for **S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**ime-framed, and is a tool to set feasible goals and to identify the different steps that are necessary for their implementation. Goals that are too abstract are difficult to break down into actions, and can leave decision-makers and practitioners feeling 'lost' in terms of how and who should initiate the implementation process. It is imperative that when a goal is set, key steps, responsibilities, time frames and budgets should be at least approximately determined.



The proposed SMART Goals for Port Louis Municipal Council based on workshop discussions are:

1. **Raising public and local government preparedness through Communication, Education and Public Awareness (CEPA):** CEPA is absolutely essential to ensure continuous capacity-building, buy-in from key local stakeholders and decision-makers, and proactive and strategic communication of immediate and long-term risks and livelihoods impacts. Inter-departmental communication within local government and sharing of responsibility is necessary to ensure that steps taken towards resilience are effective and resources and responsibilities are correctly allocated.

2. **Maintaining port security and functionality:** As the port at Port Louis is the main harbour on the island and the hub for imports and exports, maintaining the functionality of this is essential. Steps have been taken to increase the port's resilience to extreme climate events however this needs to remain a core focus of all adaptation options.

3. **Improvement of waste management and fresh water security:** There have been indications that lack of access to waste removal for certain communities leads to an increase in pollution in the rivers which in turn, leads to an increase in port pollution. Additionally, sewage waste entering the ocean can have a negative impact on coral reefs. As Mauritius has a goal of encouraging 2 million tourists annually, a healthy environment is essential. As the local environment is now seen to be drying, maintaining fresh water is non-negotiable and requires maintaining fresh water bodies and increasing water saving techniques.

4. **Procuring an advanced study of local sea level rise to address missing data**: Knowledge is the best form of preparedness and it has been acknowledged that there is not enough data at the localised level to make informed decisions such as the placement and necessity of sea walls.

The four prioritised options (listed in the box above) have been chosen based on workshop discussions and consultation with all key stakeholders. The Port Louis Municipal Council will need to design their implementation through breaking them up into deliverables and actions with assigned responsibilities. This needs to be done in ICLEI's online tool at www.ReslientAfrica.org. Some of the adaptation options will require further research and information before they can be taken to the implementation stage. The chosen adaptation options here should also be subject to a Cost-Benefit Analysis (CBA), bearing a holistic approach to risk in mind, to test their viability in the short- medium- and long-term. Remember that these options do not mean that further options should not be sought, but at this point encompass the majority of the adaptation options necessary to move towards climate resilience.

Introducing the Green Army; an example of community action

Community buy-in to a sustainable lifestyle is essential in order to result in large-scale social changes. The city of Port Louis is now being patrolled by a group of youngsters passionate about the environment who want to be a part of, and integral to social change. With membership now reaching 350 individuals, the Green Army is dedicated to anti-pollution awareness through handing out flyers while greening the city through planting trees. The Army started off small but through numerous team-building exercises and awareness campaigns has grown rapidly. Supported both financially and systematically by the Port Louis Municipal Council, the Green Army aims to plant 1000 trees around the city.

Members of the Green Army speak to ICLEI representative Lucinda Fairhurst on the steps of the Port Louis Municipal building

Additionally, a plot of land adjacent to their centre is being handed over to individuals within the Army to revegetate. Food plants are being encouraged as they can then be sold and the concept of urban farming may grow.

In May 2012 the Green Army instigated a 'green hunt', a treasure hunt where the treasure was the environment. Games within the green hunt promoted awareness of environmental factors as well as city pride and incorporated surveys to identify areas plagued with pollution or a lack of trees. Participants were given trees and followed the hunt to these problem areas where they could then plant their tree, thereby adding to a feeling of ownership and pride in the city and the environment.

7. Monitoring and evaluation

Monitoring is important for gauging if the adaptation strategies and the implemented actions work as anticipated, and to what extent they are successful. It is also a mechanism to ensure that implementation is taking place as planned and agreed. Evaluation means that each step or action that is implemented is being assessed, as well as the overarching strategies. Bearing the continuity of resilience in mind, the monitoring and evaluation process is a key component to ensure efficient use of resources and processes. It prevents unnecessary repetition and helps improve the quality and scale of the resilience-building.

Monitoring and evaluation should be built into the plan or strategy from the start, which should include a monitoring and evaluation framework, defined roles and responsibilities, a documentation protocol and a programme for evaluating results. Monitoring should be carried out throughout the entire process, while evaluation happens at strategic points in the process, and the timing of these should be included in the original planning. Monitoring and evaluation should also be budgeted for, and be carried out by skilled professionals. A good test for effective monitoring and evaluation is to ask, "What has changed since the project was implemented?".

The SMART Goals are ideal for monitoring and evaluation as they are systematic, measurable and have clear outcomes and outputs. In order to evaluate impacts and success, there also has to be baseline data, in other words something to compare with. The Baseline Study for Port Louis is a good starting point, but further ongoing documentation will be required. Documentation can take various forms, ranging from photos to meeting notes to physical improvements in infrastructure.

8. Capacity-building

Adaptation entails more than addressing the risks associated with climate variability. As the climate is changing, so too is the operating environment for local governments. Decision-making processes must therefore incorporate support and capacity-building of staff to identify the risks and opportunities that arise from changes in the biophysical and political climate.

> **"Acknowledging complexity and uncertainty as relevant dimensions in policy and decision-making regarding the management of climate change impacts requires a high level of sophistication from the risk management process and those involved. Although councils have systems to deal with change in the short term, planning rarely incorporates predictions for climatic variations in the medium to long term."** (CCP Adaptation Toolkit, 2008.)

The goal is to capacitate decision-makers and officials to think and act proactively to harness such opportunities or mitigate any risks, and not to be passive observers with reactive responses. In this project ICLEI-Africa has been working with the five local governments to build such capacity through the development of this Resilience Handbook, as well as other resources, which benefits from the experiences from the project's process and the cities' local knowledge and specific capacity.

8.1 What has been achieved so far?

Port Louis has:

- **Demonstrated international commitment**: Mauritius was the first country in the world to sign the United Nations Framework Convention on Climate Change, and has also signed the Kyoto Protocol. By signing the Durban Adaptation Charter, Port Louis has elevated its efforts to reduce its vulnerability to climate change. Such significant commitments provide Port Louis with a solid institutional platform for enhancing resilience and planning for adaptation to climate change.
- **Started the process of mainstreaming adaptation into government planning**: The participatory research undertaken through this project has contributed to making adaptation a priority for Port Louis. Also the new National Environmental Policy developed in 2007, outlines a series of thematic policy objectives and strategies to address environmental challenges which becomes a basis for local government initiatives.
- **A framework and the first steps for developing and implementing a comprehensive adaptation strategy and action plan**: This Handbook is the first step and also outlines a clear structure for the strategy and initial actions.
- **Included the needs of vulnerable communities**: A key part of the process leading up the development of this Handbook was the participation of local communities. The Stakeholder Platform has brought together representatives from these groups with government officials and other key stakeholders.
- **Given priority to sustaining and enhancing local ecosystems:** An International Convention on Ballast Water Management for ships has been adopted by the International Maritime Organisation in 2004 and applies to any ship carrying ballast water. A port baseline survey, including an inventory of the fauna and flora is being carried out by the Mauritius Oceanography Institute in collaboration with the Shipping Division of the Ministry of Public Infrastructure, National Development Unit, Land Transport and Shipping (Mauritius Environment Outlook Report).
- **Promoted and engaged in multi-level partnerships, locally and internationally:** For example the National Ports Authority of Port Louis is working together with UNEP and GEF's WIO-LaB project (Western Indian Ocean, addressing land based issues) in order to move towards adaptation and climate resilience.

The Durban Adaptation Charter for Local Governments

At the COP 17 in Durban 2011, Port Louis signed the Durban Adaptation Charter for Local Governments to "commit and upscale action to accelerate their adaptation efforts" by committing to a number of clauses:

1. Mainstreaming adaptation as a key informant of all local government development planning.
2. Understand climate risks through conducting impact and vulnerability assessments.
3. Prepare and implement integrated, inclusive and long-term adaptation strategies designed to reduce vulnerability.
4. Ensure that adaptation strategies are aligned with mitigation strategies.
5. Promote the use of adaptation that recognises the needs of vulnerable communities and ensures sustainable local economic development.
6. Prioritising the role of functioning ecosystems as core municipal green infrastructure.
7. Seek the direction of direct access to funding opportunities.
8. To develop an acceptable, robust, transparent, measurable, reportable and verifiable (MRV) register.
9. Promote multi-level and integrated governance and advocate for partnerships with sub-national and national governments on local climate action.
10. Promote partnerships at all levels and city-to-city cooperation and knowledge exchange.

Through the development of this document, and through the participatory research process of this project, a lot has already been achieved in terms of preparing for building climate resilience in Port Louis.

9. A framework for action

This section is a guide to identify the necessary steps and tasks for kick-starting the implementation of the chosen adaptation options. The ultimate aim is to increase resilience for the cities, to maintain and improve infrastructure and service delivery, and to ensure that peoples' livelihoods are secure.

Step 1: Acknowledge what has already been achieved

By participating in this project, the Port Louis Municipal Council has already built the foundation for implementing resilience. This Handbook is a result of a participatory process, and the adaptation options, risks and vulnerabilities were identified and prioritised by the stakeholders. The steps that have been taken and the knowledge gained, put the city in a position to adapt to an uncertain future through climatic changes. **This means that Port Louis Municipal Council can start immediately with defining the various steps for implementation**.

Step 2: Identify resources needed to start making decisions

It's a good idea to start with a focus group with some key people, including technical experts and community representatives. Knowing the resource requirements to implement any particular action should help to determine who should be included at this level. Think about what needs to be done and who would be the best people to implement this. You might need to have a brainstorming session, or some funding for a site visit, or more research. It is imperative that the focus groups makes tangible decisions concerning the identified adaptation options.

Step 3: Determine who the key stakeholders are

Who should be included in this process? Who has the necessary expertise or first-hand experience? Perhaps an external consultant should be brought in. What kind of political buy-in do you need? Remember that climate adaptation crosses multiple sectors so stakeholders need to be determined for every sector. As there are multiple impacts on each sector, each impact will need an action in order to move towards resilience, so again, examine who will be relevant and necessary to implement these and where necessary, identify appropriate specific stakeholder groups.

Step 4: Consider already existing institutional documents

It is imperative to consider laws, policies or frameworks at an early stage. This has multiple benefits such as avoiding repetition, ensuring a holistic approach to the task at hand, and exploring synergies, which can reduce both cost and time. Laws already in place form a solid basis from which to further mainstream climate adaptation within the local

government. Funds can then be disbursed in the most effective way, resources are correctly allocated and the collective thinking is not diluted. Working with existing institutional documents will enhance the end result of implementation and action. The Mauritian legislature already recognises the importance of the environment as well as climate change which will make implementing adaptation options more feasible through the many supporting departments.

Step 5: Analyse costs and benefits associated with the adaptation options

In order to define how much funding is required to implement the adaptation option, the costs must be analysed and weighed against the benefits. Know the intricacies of what the costs involve and what benefits they will deliver - and the time period involved. This will allow you to choose the best course of action by weighing up the pros and cons for each option. Certain actions may bring short-term relief and others, much longer term. Bear in mind that future maintenance costs should be included and assess whether the long-term costs will outweigh the benefits. Where this happens, it would be advisable to re-evaluate your actions and prioritise them again. Being a small island state located in an area frequented by extreme climatic events, Port Louis and Mauritius are particularly vulnerable to climate change impacts, the cost of inaction is likely to be very high as time passes.

This step should result in an estimated budget for the chosen adaptation options.

Step 6: Use the SMART Goal template

Using the SMART goal online template you have to break each goal into actions, deliverables, outcomes etc. and assign timeframes and measurable items. This action is perhaps the most important one so don't rush this! The local government Climate Champion together with the key stakeholders must together **spend adequate time and brain power on the SMART Goals, which will reduce the cost and time further down the line of implementation**. Bear in mind when identifying your goals the definition of the SMART Goals. They are required to be **Specific, Measurable, Achievable, Realistic and Time-Framed.**

Step 7: Identify mechanisms for monitoring and evaluation

This step means that you should decide on an overarching mechanism for monitoring and evaluation. It is a way to ensure follow-up of decisions and action, and to properly record the process. Keep your end goal in mind along with the actions being undertaken to reach the goal. Look at where in the process it is necessary to update other stakeholders, who is responsible and communicate both successes and failures. Focus on lessons learned and proper communication of these to relevant stakeholders so as to avoid repetition of mistakes, but also to capture and duplicate success.

Step 8: Incorporate capacity-building

Adaptation is an ongoing process, and key to resilience is a system's adaptive capacity. This means that stakeholders, decision-makers, officials and anyone involved in the implementation process should understand these concepts and how they transform into practice in terms of their specific tasks. To enhance peoples' adaptive capacity, and to ensure that adaptation becomes a way of doing things, and not an add-on, you need to build capacity to strengthen the institutional resilience.

Step 9: Align with CEPA

How to incorporate CEPA (Community, Education and Public Awareness) into the process should be considered at an early stage. Who should the process be communicated to? Where is the need for education and awareness? What are the key messages that we want to communicate regarding this particular process? Do we need a public face or a specific campaign? Port Louis already has installed infrastructure along rivers and in the port which will help to achieve long-term resilience. Better communication throughout all the municipal departments will achieve the necessary maintenance and responsibility required to make these initial steps have a more resounding influence.

Prepare checklists with designated tasks for stakeholders to complete. It is essential that they are able to choose the steps that need undertaking in order to effectively implement the chosen adaptation options. Keep communicating between all stakeholders and keep to deadlines as far as possible.

Task	Person responsible	Timeframe	Task complete

Having undertaken this process it is important to look at the adaptation cycle again and evaluate if 1) it is realistic that the goals will be achieved and the adaptation option successfully implemented? 2) Determine how these steps will make Port louis a more resilient Municipal Council. The steps should also consider that adaptation is a continuously evolving process that must take dynamic social, political, economic and ecological systems into account.

10. Conclusion

The Port Louis Municipal Council has already achieved a great deal as can be seen by the many good practice examples within this Handbook. Having participated in the Five-Cities Network project over the past three years, the Municipal Council has shown the necessary willingness to adapt and is well placed to achieve much more and move toward a climate resilient city.

It needs to be reiterated however, that the production of this Handbook does not indicate the end of the process, but the content and goals need to be carried forward with a continuing group of key stakeholders in order to make the goals effective. A recommended measure of carrying this out would be to officially recognise this multidisciplinary group of stakeholders, which should comprise of members of the municipal council, ministry members from all necessary departments, representatives from within the private sector, particularly where energy is the focus as there are many private suppliers, as well as industry players. If the group or platform were to be officially recognised, then it would ensure that there was a mandate given to allow for time spent by each department member, provide the necessary cross-departmental communication, and move all individuals towards the common goal.

The city of Port Louis will in the future experience the effects of the changing climate, indeed those changes are already being felt across the island. Due to the island's isolated location, Mauritius and Port Louis Municipal Council will need to rely on the ability and willingness of the ministries, industry, agricultural sectors and the general populace to all work towards sustainable adaptation in order to secure livelihoods and ensure the future of the country.

11. Further reading

The adaptation recommendations and process covered within this Handbook is based on a numerous reports, workshops and scientific papers. There have also been a number of tools developed to assist in implementing the SMART goals. To read more, the following papers and websites are recommended:

Cartwright, A. (2012) A Risk Concept Paper developed for the ICLEI-Africa project Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action.

CCP Adaptation Toolkit, (2008)

CSAG: (Climate System Analysis Group), at the University of Cape Town

Central Statistics Office. (2009). Digest of Energy and Water Statistics

IPCC (2007). The Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change

Fairhurst, L. (2009) Draft Report: City Adaptation Plan of Action for the City of Cape Town

Mauritius Environment Outlook Report. (2010)

Mauritius National Assessment Report (2010)

McSweeney, C., New, M. and Lizcano, G. (2008). UNDP. Climate change country profiles. Download at http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDP_reports/Mauritius/Mauritius.lowres.report.pdf (September 2012)

Local Interactive Climate Change Risk and Adaptation Prioritisation Training Tool (RAP tool)

Sandbrook, R. (1985) The Politics of Africa's Stagnation. Cambridge: Cambridge University Press

SREX (2012). IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

Stern, N. (2006), Review on the Economic Effects of Climate Change. Population and Development Review. 32: 793–798. doi: 10.1111/j.1728-4457.2006.00153.x

12. Glossary

Adaptation: In natural or human systems adaptation is a response to actual or expected stimuli, e.g., climate change or their effects, which moderates harm or exploits beneficial opportunities. In natural systems adaptation is reactive. In human systems adaptation can be both anticipatory and reactive and can be implemented by public, i.e., government bodies at all levels and private actors, i.e., individuals, households, communities, commercial companies and NGOs

Adaptive capacity: The ability of people and systems to adjust to environmental change, e.g., by individual or collective coping strategies for the reduction and mitigation of risks or by changes in practices, processes or structures of systems. It is related to general levels of sustainable development such as political stability, material and economic well-being, and human, institutional and social capital

Capacity-building: "Specifically, capacity building encompasses the country's human, scientific, technological, organizational, institutional and resource capabilities. A fundamental goal of capacity building is to enhance the ability to evaluate and address the crucial questions related to policy choices and modes of implementation among development options, based on an understanding of environment potentials and limits and of needs perceived by the people of the country concerned". - Agenda 21's definition (Chapter 37, UNCED, 1992.)

CCAA: Climate Change Adaptation in Africa Programme

Coastal set-back: The actual distance that a coastline moves inland due to sea-level rise

IPCC: Intergovernmental Panel on Climate Change

MRV: Measurable, reportable and verifiable

Resilience: Amount of change the exposed people, places and ecosystems can undergo without permanently changing states. That is, their ability to recover from the stress and to buffer themselves against and adapt to future stresses and perturbations

SMART Goals: Goals set to the specific requirements of being Specific, Measurable, Achievable, Realistic and Time-framed

SREX:Special Report Managing the Risks of Extreme Events and Disasters to Advance Climate Change

Subsistence: The action or fact of maintaining or supporting oneself at a minimum level

Sustainability: Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations

Vulnerability: Vulnerability is the degree to which a system or unit (such as a human group or a place) is likely to experience harm due to exposure to risk, hazards, shocks or stresses. In relation to the concept of poverty, vulnerability is more dynamic since it captures the sense that people move in and out of poverty

Annex 1 – Identified risk per sector

Water and Sanitation

Impacts: Water and Sanitation	Impacts: Livelihoods
• Damage to water supply infrastructure • Deposition of mud and contaminants in urban freshwater supply and dams • Increased wave action and flooding along the coast • Flooding causing strong water flows in aquifers • Flooding of storm water pipes • Damage to properties and infrastructure • Increased sand depositions • Erosion and landslides which may damage (storm water) infrastructure and assets even more • Increase in storm water pollution • Wind may cause a greater drying effect	• Increased pressure and need for water supplies for irrigation • Blockages and silting of storm water ways • Increased need for maintenance, upgrades or replacement of infrastructure (e.g. storm water facilities) • Some water supplies / dams offline and thus increasing pressure on remaining water sources and potential water restrictions • Knock on effect on health as a result of increased changes of contamination of fresh water sources. • Cases of Dehydration • Poor water access • Poor water quality

Transport

Type	Impacts: Transport	Impacts: Livelihoods
Road	• Damage of infrastructure • Blockage of roads (fallen trees, debris) • Flooding causes diversions • Accidents • Inundation of roads • Road closures on bridges and mountain passes • Damage to signage and overhead cables • Erosion of bridges	• Traffic jam and increased waiting time • Limits access routes • Delays to the work place and markets • Work hours lost– reducing income • Risk to public safety
Rail	• Damage of infrastructure • Blockage of railway tracks (fallen trees, debris) • Erosion of railway infrastructure • Inundation of railways • Disruption of electronic transport infrastructure • (e.g. train signals) • Expense of maintenance	• Causes delays and cancellations of trains • Unable to reach destination • Work hours lost– reducing income
Air	• Damage of infrastructure • Accidents and air crashes • Reduction in GDP • Airport closes for safety during cyclones • Increased insurance required by operators	• Reduces accessibility to airports • Delay in exports/imports • Decreased safety

Port	• Damage of infrastructure • Erosion to coastal infrastructure and equipment • Damage of boats • Erosion to harbour wall • Damage to anchored boats	• Days at sea lost • Work hours lost – reducing income, if the port is rendered unworkable, then there is no income stream until the damage has been cleared. • Delay in exports/imports • Increased insurance premiums

Health

Impacts: Health	Impacts: Livelihoods
• Damage to clinics, hospitals and other infrastructure and services • Increased pressure on emergency services. • Service delivery backlogs in clinics and hospitals • Chemical Hazards: contamination of flood water with oil, diesel, pesticides, fertilisers etc. • Spread of infectious diseases: skin and respiratory diseases and stomach ailments. • Worsening of existing chronic illnesses • Long-lasting psychological impacts • Higher wind speeds and changes in air pressure cause people to feel unwell (i.e. headaches) • Increased drying effect • Increased health threats through heat stress • Disruption of solid waste management • Loss of hygiene and sanitation = increased pests and vectors	• Increased deaths from: ○ Drowning ○ Electrocution ○ Injuries cause by windblown debris • Increased casualties • Hours of work lost • Medical bills to pay • Poor and limited water supply to residents • Dehydration • Loss of shelter • Likely to affect vulnerable communities (young, women and elderly) most at risk to infection and health risks and impacts associated with severe extreme events. • Food scarcity

Energy

Impacts: Energy	Impacts: Livelihoods
• Erosion of coastal power lines • Damage and losses to energy production facilities and infrastructure (power stations, high voltage lines etc.) • May cause an increased demand for energy • Extreme temperatures increase the demand of energy as cooling facilities are employed • Power outages due to floods destroying power lines • Energy supply cut for bore hole water pumping • Loss of economic activity unless alternate energy supplies are in position	• Chances of electrocution by live wires being submerged in floodwater • Limited fresh produce for consumption • Limited water supply if water sector does not have backup generators causing dehydration • Inability to boil water to ensure water is potable and to prevent the spread of cholera and other water-borne diseases

Annex 2 – Local adaptation options

Below follows the complete list of the adaptation options identified through the Port Louis stakeholder workshops.

Increased tropical cyclone activity – adaptation options

Community Based Adaptation Options:

- Prepare Solar Lanterns to ensure lighting when strong winds disconnect electricity supply
- Removal of roof antenna
- Self cleaning of roofs
- Establish roof gardens and vegetate areas of exposed soil
- Secure all structures (to avoid loss of property or assets)
- Boil water during and after storms to ensure consumption of clean water
- Stock up on Provisions
- Communication, Education and Public Awareness (CEPA) of necessary medicinal options and treatment facilities
- Community involvement (especially at refugee centres)

Institutional Adaptation Options:

- Establish a Key Stakeholder Platform to inform decision making processes;
- Structure building guidelines;
- CEPA (Through cyclone committee);
- Limit low lying development;
- Cyclone Early Warning Systems (Already been done by the Met Office including stakeholders such as the police; fire services and disaster committee)
- Risk and vulnerability maps;
- Coastal Protection Zones;
- Integrated Development Plan;
- Explore alternative access routes;
- Forward planning.

Biophysical Adaptation Options:

- Establish and increase permeable surfaces to allow water to be easily filtrated and not evaporated during increased winds and high temperatures;
- Vegetate areas to limit windblown sand;
- Establish roof gardens to reduce heat island affect;
- Re-establish coastal areas to protect natural dune buffers;
- Increase wind breaks along transport routes to reduce strong wind on main highways.

Infrastructural Adaptation Options:

- Structural wind breaks to reduce wind in certain areas;
- Availability of pumps and generators at medical facilities in times of power outages;
- Underground cabling to reduce disconnection of energy supply during high winds;
- Alternative routes in times of blocked roads.
- Wind breaks along coastal areas to protect terminals and storage petroleum units at the Port Louis harbour;
- Raise harbour defences to protect the harbour facilities from sea swells during strong wind events.

Retreat Adaptation Options:
(The Authorities that are delivering and maintaining the services of the infrastructure within the local or central government are stated below in parenthesis)

- Relocate Transport Routes
- Move Clinics and Hospitals (Ministry of Public Infrastructure)
- Water Diversions (Central Water Authority)
- Relocate Water Treatment Plants (Central Water Authority)
- Relocate Petroleum Storage Plants (Private and Central Government)
- Relocate Gas Storage Tanks (Private and Central Government)
- Relocate Sugarcane Port Terminal (Parastatal – Ministry Chemical Fertiliser Industry) [60% exported in containers]
- Power Station and Forte George (Central Electricity Board)