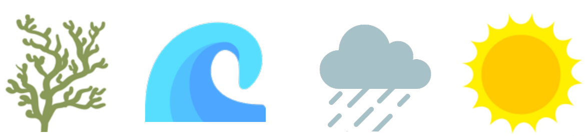
Why use a Climate Scenario Toolkit?

The purpose of this toolkit is to help local planners and decision-makers envision different climate scenarios to better plan for a future that will likely look very different from the past in terms of weather and climate. The approach, developed by U.S.-based Great Lakes Integrated Sciences and Assessments (GLISA), has helped local communities prepare for changing climatic conditions. The information in this toolkit has been developed specifically for the Seychelles context and can be applied to guide many climate-related policy documents such as the Seychelles National Setback Policy, National Climate Change Strategy, or Coastal Management Plan.

The aims of this toolkit are to:

- Familiarize users with local climate trends, features, and future scenarios
- Provide a set of climate scenarios tailored to the policymaking needs of the Seychelles
- Help users better understand scenario planning
- Allow users to more clearly be able to picture how Seychelles natural resource management activities are impacted by weather/climate



What are Climate Scenarios?

A climate scenario is a description of future climate conditions. Climate scenarios may be both qualitative and quantitative and they vary in the amount of detail that is included, based on the needs of the end user. Typically, greater amounts of detail (i.e., descriptions beyond how annual temperatures and precipitation might change) make the scenarios more tangible for users and policymakers to incorporate into their planning, but those details do not necessarily need to be quantitative.

Ultimately, most users are interested in climate scenarios as a means to explore potential future impacts on people, resources, and the environment. The climate scenario framework presented here looks at possible future outcomes without assigning them specific probabilities. This supports an equal exploration of both high risk/low probability events and low risk/high probability events, fostering broad adaptation discussions covering many possible futures.

How were the Climate Scenarios developed?

The five climate scenarios presented here were developed using several climate models downscaled to make better local projections for the Western Indian Ocean/Seychelles region. The climate scenarios will address four primary management concerns identified by Seychellois stakeholders in field interviews, as well as a few others:

- Flooding in Victoria and other low-lying areas
- Damage to coastal infrastructure
- Coastal/beach erosion
- Coral bleaching

The management concerns and the five climate scenarios developed around them are provided in the climate scenarios section on page 4.

A man walks along a rock wall at Bel Ombré in Mahé, Seychelles

The remainder of this toolkit guides the user through Seychelles' current seasonal climate, future climate trends, and local climate system feature, which then feed into the five climate scenarios tailored for Seychelles.

This toolkit is meant to aid decision-making by Seychelles' climate and natural resource policymakers. The toolkit is designed for use by any group (government department, NGO, business) seeking to undertake climate adaptation. The toolkit works best when multiple decision-makers collaboratively engage with it and address management goals from multiple perspectives.

The following steps are involved:

Step 1: <u>Familiarize</u> yourself with Seychelles climate trends, features, and future scenarios

Step 2: <u>Compare</u> the impact of local climate events on adaptation management goals

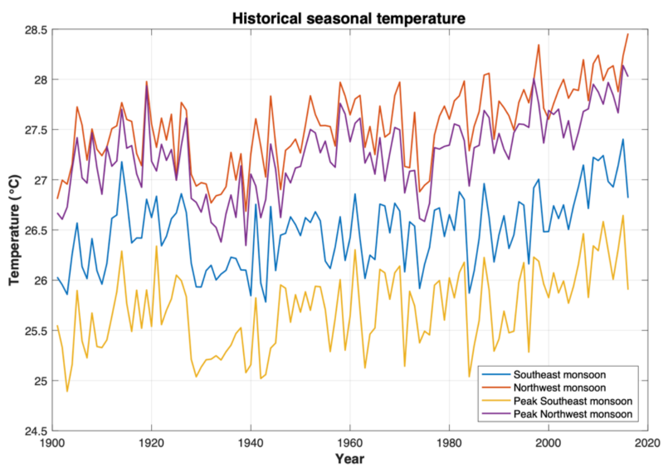
Step 3: <u>Develop</u> climate adaptation goals, make plans to achieve them, and explore future challenges

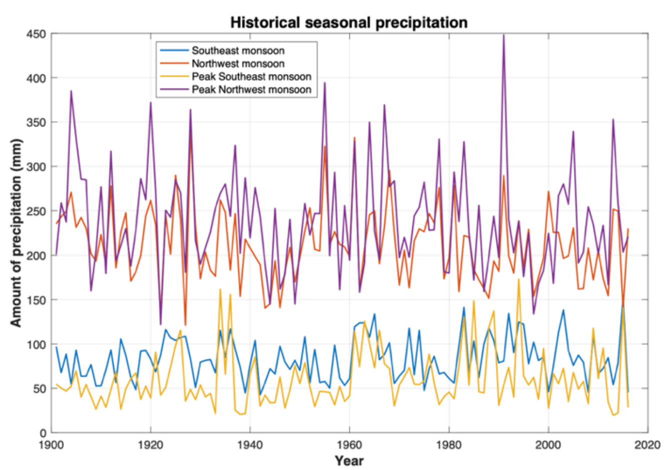
Step 1: Familiarize yourself with Seychelles climate features, trends, and future scenarios

Current Climate in Seychelles

Seychelles' annual climate can be broken down into two monsoonal seasons: From May to October, the Southeast Monsoon brings a relatively dry period which reaches its peak from July to August. During this time, there is very little precipitation and the average high temperature is 27°C. By November, the winds start to change, bringing lighter, warmer winds and the start of the Northwest Monsoon, the main rainy season. From December to March, Seychelles experiences consistent precipitation, reaching its peak in December and January. The average high temperature during Northwest Monsoon is 30°C.

Below are two figures depicting the historical trends for temperature and precipitation in Seychelles. These figures show the stability of the monsoonal effect over the last 118 years, with significant differences between general monsoonal conditions and peak conditions. These trends may affect the seasonality of management plans.





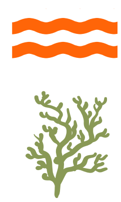
Open-source temperature and precipation data charted from 1900-2018 showing stability of monsoonal trends

Future Climate Trends for the Seychelles

The following are projected to be the key effects of climate change in Seychelles:

General Warming and Precipitation: According to downscaled CMIP5 projections for the Seychelles region, mean annual temperature will rise by 1.5°C in 2050 and mean annual precipitation will rise by 70.1mm in 2050. Both monsoonal trends are expected to amplify—this means a wetter Northwest Monsoon (December-March) and a drier Southeast Monsoon (May-October) by the end of the century. Projected monthly temperatures also reflect amplified monsoonal trends, with the Northwest Monsoon months experiencing a greater temperature increase than the Southeast Monsoon months.

Sea Level Rise: While current scientific projections show a global sea level rise rate estimated at between 2 and 3 millimeters per year, rates of sea level rise are not uniform across the globe. Large regional differences have been detected in the Indian Ocean and tropical Pacific, where some regions have significantly higher sea levels than the global average. Generally, regions at the lower-to-mid latitudes are projected to experience a more severe change in sea level than regions in the upper latitudes; this means Seychelles may face higher sea level rise than the global predictions. The IPCC's 2019 *Special Report on the Ocean and Cryosphere in a Changing Climate* predicts a .84m increase by 2100, under its high emissions scenario (RCP 8.5).



Sea Surface Temperature and Coral Reef Temperature: Under a high emissions scenario (RCP 8.5), sea surface temperatures of the world's sub-tropical gyres, which includes the Indian Ocean sub-tropical gyre and Seychelles, are projected to be 0.45°C to 0.91°C warmer in the near term (by 2039) and 1.90°C to 3.44°C warmer in the long term (by 2100). These changes in temperature are very likely to increase water column stability, reduce the depth of the thermocline, and influence key parameters like nutrient availability. Year-round sea surface and deeper coral reef water temperatures are projected to increase from 0.07°C to 0.14°C per decade.

Climate Features of the Seychelles

In order to properly create climate scenarios specific to the Seychelles, it is helpful to understand the climate and ocean processes that affect local climate trends and weather events. These are briefly described below, as are their expected changes resulting from climate change:

Atmospheric-Oceanic Features

Somali Jet: The Somali Jet is a low-level jet that transfers moisture north toward India from the equatorial latitude in boreal summer and reverses its moisture transfer in winter. As the Somali Jet carries moisture away from the equatorial zone in summer, Seychelles experiences its dry monsoon season. Conversely, as the jet reverses its trajectory and brings the moisture back down to the equatorial zone in winter, Seychelles experiences its wet monsoon season. The Somali Jet is generally expected to weaken with climate change, possibly negatively impacting the moisture content of Seychelles' winter monsoon.

Madden-Julian Oscillation (MJO): The MJO is characterized by the eastward progression of large regions of both enhanced and suppressed tropical rainfall, usually first observed over the Western Indian Ocean. Typically, strong MJO winds cause dry winds from the coast of East Africa to travel across the Indian Ocean, which may pause precipitation in the Seychelles during boreal summer. Meanwhile, the winter MJO moves in a sort of see-saw motion after forming in the east, bringing moisture back over the Seychelles. Climate change is projected to strengthen and accelerate the MJO. The timescale between changes in oscillation will be shorter, and this will increase the variable heat and humidity in the Seychelles region.

Indian Ocean Dipole (IOD): The Indian Ocean Dipole is an irregular oscillation of sea surface temperatures in which the western Indian Ocean, off the coast of East Africa, becomes alternately warmer (positive phase) and then colder (negative phase) than the eastern part of the ocean, close to Australia and Southeast Asia. This causes increased rainfall over the western Indian Ocean region (encompassing Seychelles) during a positive phase and decreased rainfall during a negative phase. The frequency of positive IOD events is projected to increase linearly as the warming proceeds. This may lead to increased moisture convection and precipitation in the Seychelles region.

Topographic Feature

Mascarene Plateau: The chain of Seychelles islands sits atop the Mascarene Plateau, a submarine Plateau that curves around Madagascar in an inverted "C" shape and encompasses Seychelles, Mauritius, and Réunion. The plateau covers an area of over 115,000 m^2 of shallow water before plunging 4,000 meters at the edge of the abyssal plane. This vast area of shallow water allows for unique climatological and oceanic features that are specific to the southwest Indian Ocean.

Topographic-Oceanic Feature

Seychelles Dome: The Seychelles Dome is the combination of a shallow oceanic thermocline (layer of water dividing upper mixed layer with deep calm water below), and high sea surface temperatures sitting atop the western half of the Mascarene Plateau. This combination of shallow underwater topography and shallow thermocline yields abnormally high sea surface temperatures year-round. The Seychelles Dome is not constant, fluctuating between a strong phase that causes more upwelling of cold water (shallow thermocline) and a weak phase that causes less upwelling of cold water (deeper thermocline). Regarding climate change effects, when considering the impact of a positive IOD on the Seychelles Dome—IOD, deepens the thermocline and warms the sea surface temperature in the western part of the Indian Ocean—it can be extrapolated that an increase in positive IOD occurrence will deepen the Seychelles Dome thermocline and increase sea surface temperature warming in the region. It is also possible that strong MJO winds prompt a deeper thermocline and more upwelling, which will slow the rate of coral reef die-off.

Geologic Feature

Granitic Island Chain Structure: Seychelles geology plays a role in climate events, as when you cut into granitic rock, which is necessary for infrastructure development on Mahé and the other main islands, it becomes less stable and is more likely to experience rock falls. The dynamics between local weather events and local geology play a role in climate event as well—rainwater is naturally slightly acidic, and as a result will "chemically erode", or dissolve, the silica in granite over time, increasing its susceptibility to rock slides. Extreme precipitation can trigger landslides and tree falls by transporting the rockslides down the side of the mountain.

Five Climate Scenarios for the Seychelles

Although there are several common themes among the projections for Seychelles, the changing climate, oceanic, and oceanic-topographic features offer differences to explore. Five distinct climate scenario frameworks were developed by accounting for climate stressors unique to each management area. The scenarios, four wet and one dry, represent *possible* outcomes of climate change without assigning them specific probabilities. They are meant to be compared with one another qualitatively as opposed to probabilistically. The development of an adaptation plan addressing these scenarios is discussed in Step 3 (page 6).

Some caveats: Uncertainty and Feedback Loops

The development of these scenarios relied on IPCC climate models. However, like any model, climate models cannot perfectly predict future conditions. Most of the figures obtained for the General Climate Trends section of this toolkit were created by CMIP5, the 5th iteration of the IPCC's amalgamation of 16 global climate models. The latest version, CMIP6, may be more accurate in its predictions, which have more dire climate outcomes than CMIP5. The scenarios presented here use the most extreme CMIP5 projections (RCP 8.5, High Emission) on the basis that the most severe projections in CMIP5 are more similar to moderate projections in CMIP6. Ideally, this toolkit could be routinely updated to include the latest climate projections.

While this toolkit presented climate features and trends separately (page 2 and 3, respectively), these elements do not operate independently of each other. Well-documented relationships and feedback loops have been studied between each component. While these interactions are not covered in detail here, it is important to keep in mind that a change in one climate feature could exacerbate or, conversely, moderate a change in another. Future climate models will better account for these interactions and, in turn, generate better predictions. The interactive relationships between some of Seychelles' climate features are explored more thoroughly in the [LAKI report](https://bit.ly/2yjDNs9) (https://bit.ly/2yjDNs9) that accompanies this toolkit.

Warm and Wet Scenarios

1. Extreme rain

- → Increase in seasonal/monsoonal precipitation, with highest increase in extreme precipitation
- → Increased occurrence of flooding in downtown Victoria and other low-lying areas
- → Shorter time intervals between flooding
- → Increased occurrence of rock debris falls, possibly impacting inland infrastructure and private property
- → More extreme rain after seasonal rain, possibly increasing mudslides

2. Low sea level rise, extreme storm surge

- → Slow but continuous coastal erosion
- → Increase in extreme storm surge events, possibly impacting critical coastal infrastructure and fishing industry
- → Shorter time intervals between extreme storm surge events
- → Possibility of increased storm tides

3. High sea level rise, warmer sea surface

- → Increased rates and occurrences of coral bleaching
- → Disruption of marine ecosystems
- → Accelerated coastal erosion, possibly impacting critical coastal infrastructure and private property
- → Possibility of increased soil salinity, affecting agriculture yields and transformation of mangrove systems
- → Possible overwhelming of drainage systems

4. Wind-related upwelling

- → Increase in MJO-related westerly winds
- → Related increase in cold-water upwelling in Seychelles Dome region→ decrease in sea surface temperatures
- → Reduced coral bleaching
- → Reduced sea surface warming effect on marine ecosystems

Extended Warm and Dry Scenario

5. Drought

- → Increase in likelihood of wildfires
- → Increase in stagnation of water bodies, leading to increase in proliferation and spread of disease-carrying vectors
- → Diminished supply of water for public consumption, industrial uses, and agricultural uses

Step 2: Compare the impact of weather events and climate trends

Now that you have familiarized yourselves with Seychelles' climate trends, features, and the five climate scenarios, it is time to look at how local climate and weather events impact your management goals. The aim of this exercise is to understand the relative impacts of projected climate trends in order to prioritize your adaptation efforts.

In the table below, please rate the impact of the listed weather events and climate trends on your management goals **by putting a check mark on either Low Impact, Medium Impact, or High Impact**. If the seasonality of the event matters, please take note of that in the column along with your rating. You may also list and rate additional climate events by adding them to the last two rows in each table (labeled *other*).

Weather Events	Low Impact	Medium Impact	High Impact
Very hot days			
Heavy precipitation/storm events			
High windstorms			
Multiple consecutive days with rain			
Multiple consecutive days without rain			
Other:			
Other:			

Climate Trends	Low Impact	Medium Impact	High Impact
Warmer annual and seasonal temperatures			
Increased annual precipitation			
Altered timing of seasonal precipitation			
Prolonged periods of drought			
Prolonged periods of moist conditions			
Increased coastal flooding			
Increased beach erosion			
Other:			
Other:			

Combined Weather Events & Climate Trends	Low Impact	Medium Impact	High Impact
Extreme precipitation event during an extended dry period (any time of the year)			
Several consecutive dry summers interrupted by a particularly wet summer			
Several consecutive wet summers interrupted by one or multiple dry summers			
Other:			
Other:			

Step 3: Develop climate adaptation goals, make plans, and explore future challenges

For each of the five climate scenarios, what goals should be set in your group to help the community adapt to the projected climate changes? What steps must be taken to achieve each of the goals? What challenges will need to be overcome in each scenario to achieve the adaptation goal? Are there contingency plans to counteract these potential climate- and weather-related challenges?

The table below provides a matrix for you to consider these questions for each of the scenarios. It likely provides too little space for your input so feel free to use a separate document. For group efforts, a whiteboard or blackboard can be helpful.

Climate Scenarios	*Scenario 1.* *Extreme rain*	*Scenario 2.* *Low sea level rise, extreme storm surge*	*Scenario 3.* *High sea level rise, warmer sea surface*	*Scenario 4.* *Wind-related upwelling*	*Scenario 5.* *Drought*
Set a goal: How can your group adapt to each climate scenario?					
Examples of adaptation goals	Improve stormwater system capacity	Storm-proof downtown infrastructure	Prevent saltwater intrusion	Help coral systems benefit from increased upwelling	Prepare for increased likelihood of wildfires
Make a plan: What steps do you need to take to achieve your adaptation goals? When should these steps be completed?					
Examples of one step in a plan	Increase catch basin retention + detention	Reinforce + weatherproof building fronts	Increase natural saltwater filtration systems	Prioritize areas of strong upwelling for coral transplants	Increase frequency of prescribed burns (esp. in residential areas)
Explore challenges: What challenges do you foresee arising in each climate scenario?					
Examples of challenges	Flooding may delay construction projects	Increased storm surge may damage infrastructure	Saltwater intrusion threatens local brackish ecosystems	Will be difficult to determine hardiest coral species for transplant	Decreased water supply with which to fight wildfires