Plan for a Green Economy

OASIS

A PROGRAM TO PREVENT AND REDUCE THE RISKS ASSOCIATED WITH CLIMATE CHANGE THROUGH GREENING

GUIDELINES FOR TERRITORY-WIDE GREENING PLANNING AND FOR THE PRODUCTION OF RISK ANALYSES RELATED TO HEAT AND HEAVY RAINFALL

Votre gouvernement

Québec

COORDINATION AND EDITING

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TO OBTAIN INFORMATION ON THE PROGRAM

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Glossary

Adaptive capacity
Adaptive capacity is the ability of individuals and organizations to protect themselves from climate change impacts or react to them.

Average annual number of days of precipitation > 20 mm
The number of days in a year on which the volume of precipitation (rain and snow combined) is 20 mm or more (donneesclimatiques.ca).

Consequence – Impact – Effect
The repercussions of weather hazards can affect the lives and physical and psychological health of individuals and cause damage to or the loss of infrastructure. Under this approach, the terms consequence, impact, and effect are synonymous.

Pluvial flooding
Flooding due to heavy rainfall independently of overflow from a water body or a watercourse, although both phenomena can simultaneously affect a territory. In urban environments, pluvial flooding are linked to heavy rainfall and defined as flooding caused by surface runoff such as stormwater runoff and infrastructure flooding, including storm sewer overflows in streets. They are mainly caused by excess runoff in developed areas where the water is trapped, which overloads technical and non-technical drainage systems. They are exacerbated by the impermeable surfaces such as concrete, asphalt, and big waterproof roofs that in most cases are found in built zones and by the general concentration of development (adapted from *Gros plan sur les types d'inondations,* Institut de prévention des sinistres catastrophiques, ICLR_Flooding_F_2021.pdf).

Exposure
Exposure stems from the presence of individuals, infrastructure, or economic, social, or cultural assets in locations or contexts likely to sustain damage related to weather hazards.

Maximum one-day precipitation
The greatest amount of precipitation (rain and snow combined) that falls within a 24-hour period (donneesclimatiques.ca).

Number of heatwaves
The number of events where the temperature exceeds a certain threshold for three consecutive days (portclim.ouranos.ca)

Risk
The combination of the probability of occurrence of the consequences of a weather hazard and the seriousness of such consequences with respect to vulnerable elements, including people, in a given environment. Probability changes in light of changing climatic conditions and conditions in the given environment. A risk that materializes becomes a consequence and, conversely, a potential consequence is a risk.

Risk analysis
In the context of this guide, risk analysis is a process that pinpoints risks related to heat and heavy rainfall in the current and future climate for vulnerable individuals and infrastructure and their spatialization in the territory, and ascertains the level of such risk.

Sensitivity
The degree to which an exposed element is affected by weather hazards.

Vulnerability
The condition stemming from the physical, social, economic, or environmental factors that predispose the elements exposed to the outward sign of a weather hazard to sustain harm or damage. Climatic vulnerability stems from interaction between three parameters, i.e., exposure to weather hazards (weather events), sensitivity, and adaptive capacity.

Weather hazards
Weather hazards can pose threats or cause damage. In the context of the OASIS Program, they include heat or heavy rain that leads to pluvial flooding that are likely to adversely affect a territory’s population and infrastructure.

1. Context

The OASIS Program seeks to enhance the resilience of Québec communities faced with longer, more intense, more frequent heatwaves and more intense, more frequent heavy rainfall. To do so, it financially supports municipal bodies and the Indigenous communities in the planning (Component 1), realization (Component 2), and the perpetuation (Component 3) of greening projects in Québec communities. The guidelines presented in this document apply to greening planning and risk analysis carried out under the OASIS Program.

The risk analyses to be carried out must target populations and infrastructure. The government is seeking through this program to reduce the risks that heat can pose for human health and that risks related to pluvial flooding stemming from heavy rainfall can pose for infrastructure.

Such risks will change in the coming years and decades because of climate change. The planning of greening projects must, therefore, consider such change to ensure that the green infrastructure implemented satisfies current and projected risks that weather hazards such as heat and heavy rainfall pose.

The risk-analysis approach presented in this document seeks to analyze the risks related to heat and precipitation and their development over time and guide their spatialization in the territory of the municipal body or the Indigenous community.

2. Objective

The guidelines presented seek to provide a framework for the execution of risk analyses that adequately target risks related to heat and heavy rainfall throughout the territory of municipal bodies and to guide response planning:

- the choice of zones where it is necessary to intervene in the territory of the municipal bodies and the areas within such zones where intervention has priority;
- the location and type of green infrastructure to be established.

This document describes the minimum requirements such as the elements of the approach and the choice of certain parameters, to engage in greening planning by means of a risk analysis funded under Component 1 of the OASIS Program. This is the basis on which greening planning by means of a risk analysis already carried out and appended to an application for funding under Component 2 of the OASIS Program will be evaluated, if need be.[1]

[1] The applicants can have already carried out a comprehensive risk analysis at the municipal level, which can be used for an application for funding under Component 2 of the program provided that it covers risks related to heat and heavy rainfall (pluvial flooding) covered by the program.

3. Risk analysis approach: General considerations and stages

There are different recognized risk analysis methodologies related to climate change impacts. Aside from the approach presented here, several of them can be deemed equivalent and acceptable for the greening planning funded under Component 1 of the OASIS Program:

- ISO 31000: Risk management
- ISO 14091: Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment.

Figure 1 presents an overview of the stages in the risk analysis respecting populations and infrastructure in the territory of the municipal body or the Indigenous community to provide a comprehensive view of the approach.

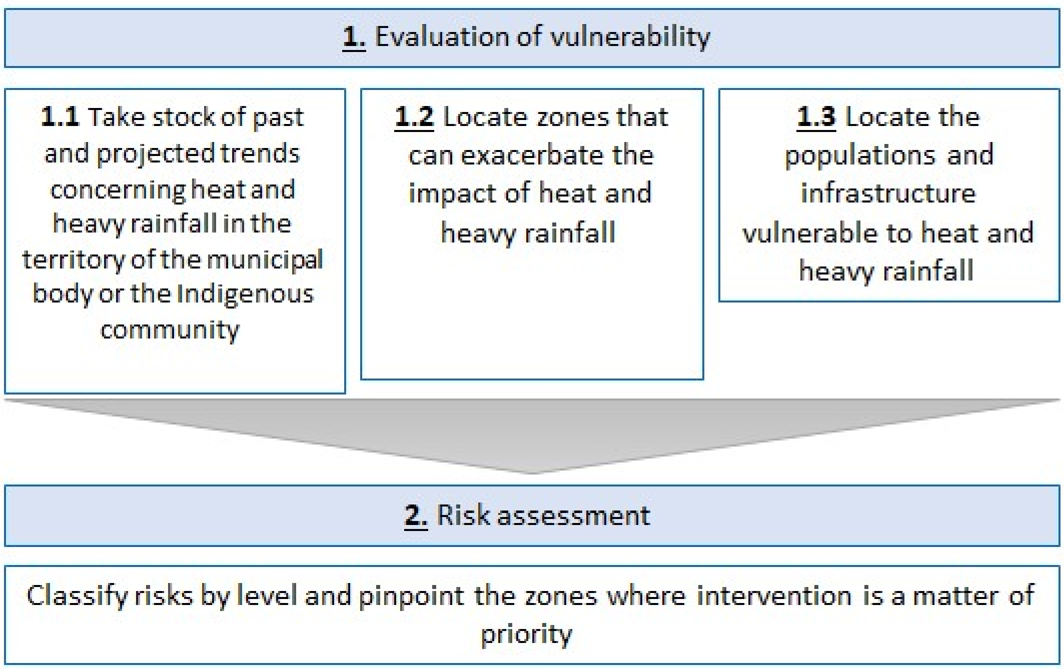

Figure 1: Stages in risk analysis

The vulnerability assessment is the first stage in the risk analysis. It consists in:

- taking stock of past and projected changes in heat and heavy rainfall in the territory;
- identifying and describing the zones that can exacerbate heat and heavy rainfall;
- identifying and describing the populations and infrastructure that are vulnerable to heat and heavy rainfall.

Risk assessment is the second stage in the risk analysis. It makes the connection between the information collected in the previous stage. It allows for the classification of risks by level and the prioritization of intervention in a risk matrix.

The risk analysis ultimately guides the choice of zones where intervention takes priority in the territory and the location and type of green infrastructure to be established to satisfy in the best possible manner the risks pinpointed.

4. Requirements pertaining to the risk analysis and planning approach

In this section, elements in **bold face** are mandatory elements of the approach, i.e., depending on the circumstances, the stages or parameters to be used. Should the information requested not be available, applicants are asked to find an equivalent or to use the best qualitative description possible.

The risk analysis produced must **comply with the following parameters**:

- geographic scope: the risks must **be studied in the territory overall** of the municipal body or the Indigenous community;
- temporal scope: **2041-2070 and 2071-2100,** the current time horizons, must be considered;
- target object: the **population of the territory** of the municipal body or the Indigenous community and the **infrastructure in the territory** that **pluvial flooding can affect;**
- targeted risks: the elements under consideration are **heat-related risks to public health** and **pluvial flooding risks with respect to infrastructure stemming from heavy rainfall.**

1. Evaluate the vulnerability of the populations and infrastructure in the face of heat and heavy rainfall in the territory

1.1. Take stock of past and projected changes in heat and heavy rainfall in the territory

1.1.1. Choose the climate indices

To describe the heat and heavy rainfall episodes, **it is minimally necessary to study the climate indices indicated below.**

Heat-related climate indices:

- the number of heatwaves[2] whose temperature thresholds correspond to those established by the Institut national de santé publique;
- the annual number of days on which the maximum temperature exceeds 30°C.

[2] The minimum and maximum temperature thresholds that quality as heatwaves vary by region in Québec ([Vagues de chaleur [monclimatmasante.qc.ca]]). It is important to choose the heatwave index corresponding to the region in which the risk analysis is produced.

Climate indices related to heavy rainfall:

- the average annual number of days of precipitation > 20 mm;
- the maximum one-day precipitation.

These and other climate indices can be consulted on the Portraits climatiques and Données climatiques Canada websites.

1.1.2. Describe from the standpoint of the recent climate the climate indices chosen and describe the extreme weather events related to heat and heavy rainfall that have occurred in the past

The examination of the climate indices chosen in step 1.1.1 with respect to the recent climate will provide a reference to ascertain the change in such indices between the recent climate and the future climate that is obtained in step 1.1.3.

The reference period to consider with respect to the recent climate is 30 years,[3] i.e., from 1991 to 2010, according to the most recent data available.

An examination that goes as far back in time as the data allow of extreme weather events related to heat and heavy rainfall reveals the occurrence of rarer, but significant, events whose future intensity, duration, or frequency climate change could amplify. **The historical background of extreme weather events related to heat and heavy rainfall in the territory must be presented when available.**

The study from the standpoint of the recent climate of the climate indices chosen and the study of past extreme weather events related to heat and heavy rainfall will facilitate the targeting of the most immediate risks related to heat and heavy rainfall that are already affecting or will soon affect people and infrastructure in order to manage and prevent them.

1.1.3. Project from the standpoint of the future climate the climate indices chosen and present their temporal variation

Climate change will affect heat and heavy rainfall. To ascertain the impact of climate change on such weather hazards, **climate projections must be used to analyze changes in the climate indices adopted in step 1.1.1.[4]**

Through climate projections it will not only be possible to ascertain for the territory and according to the climate indices adopted in step 1.1.1 average changes in climatic conditions but also changes in extreme events, whose intensity, duration, and frequency may be modified.

[3] A 30-year period is consistent with the recommendations of the World Meteorological Organization and is deemed sufficiently long to avoid average climate indices being tinged by the variability of the short-term climate (excerpt from the *Guide sur les scénarios climatiques* d'Ouranos, GuideScenarios2016_FR.pdf [ouranos.ca]).

[4] The Portraits climatiques and Données climatiques Canada websites allow for the projection of climate indices according to different emission and time horizon scenarios.

The time horizons to be used are 2041-2070 and 2071-2100.

Aside from the data for these time horizons being readily accessible, the use of several time horizons reveals that climate models well and truly forecast that climate change will affect the climate variables targeted, which suggests that risk will increase over time.

To obtain an overview of possible futures, **it is necessary to use at least two greenhouse gas emission scenarios (radiative forcing), including an average emission scenario (RCP 4.5) and a high emission scenario (RCP 8.5)** to produce the climate projections.

Indeed, considering the uncertainty surrounding global greenhouse gas emission trajectories and the attendant climate change, the use of the two scenarios allows for the presentation of two profiles of climate indices that may prevail in the future in the municipal territory. It reveals whether the issues are similar or, to the contrary, very different in light of the two scenarios.

The projections carried out will provide an overview of the scope of possible futures from the standpoint of heat and heavy rainfall in the territory over different time horizons.

All told, **four projections must be produced for each climate index selected** (two emissions scenarios X two future time horizons). **In a table** (see Table 1 below), **present the values associated with each climate index for the recent period and for the four climate projections**.

Table 1: Example of a table that presents the values associated with two climate indices for the recent period and for the four climate projections

Climate index	Recent	2041-2070		2071-2100	
	1981-2010	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Example: Annual number of heatwaves	0.17	1.37	2.43	1.97	5.33
Example: Annual number of days of precipitation > 20 mm	8	10	11	10	12

The projection of the climate indices is not used directly in greening response planning in the field. However, it allows the municipal body to ascertain whether climate change will affect the climate indices related to human health risks and infrastructure flooding risks and illustrate the scope of the potential change in risks in the coming decades. It also demonstrates the preventive nature of the greening initiatives carried out, facilitates broader understanding of the extent of future benefits stemming from the greening initiatives carried out now, and explains the relevance of the investments made now in greening to combat climate change.

1.2. Pinpoint and describe zones that can exacerbate the impact of heat and heavy rainfall: heat island zones and zones that are or could be affected by pluvial flooding

Certain zones accentuate the impact of heat and heavy rainfall, especially heat island zones and zones subject to pluvial flooding. **Such zones must be located in a geographic information system[5] and described for the overall territory targeted.** The extent of such zones could alter in the future because of climate change and measures pertaining to urban planning and wastewater and stormwater infrastructure management.

The information pertaining to heat island zones in the geographic information system must include the **zones that are deemed "hot" and "very hot" according to the urban heat island map.[6]**

As for zones subject to pluvial flooding, the information in the geographic information system must include the **zones where pluvial flooding have occurred or are likely to occur.** In addition to the **zones directly affected by water accumulation or that may potentially be affected, the zones that contribute to draining** the water through surface runoff and subsurface drainage towards a site thereby causing flooding **must also be pinpointed.**

In addition to the map data available on various platforms that can be used to determine such zones, experts can be questioned in order to ascertain, for example, where overflowing storm sewers or surface runoff have caused pluvial flooding in the past. Consultations can also be held to take advantage of local knowledge.

1.3. Identify and describe the populations vulnerable to heat and infrastructure vulnerable to heavy rainfall in the territory

Step 1. Determine the location of the populations vulnerable to heat. To this end, use the gross vulnerability index available in the cartography of vulnerability to heatwaves.[7] Vulnerability indices can be grouped together in three categories: very low to low, moderate to average, and high to very high. **Moreover, sites likely to assemble vulnerable populations,** e.g., day care centres, schools, hospitals, residential and long-term care centres, and low-income housing **must be identified in the geographic information system and include a buffer zone of at least 300 m.[8]**

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[5] Data must be in an open format, e.g., shapefile or KML. It should be noted that the KML format is mandatory to submit a project under Component 2 of the OASIS Program.

[6] To properly view the zones, click on the menu in the upper left-hand corner of the screen. Next, click on "Ma carte,", then conceal "Température de surface (2012)" and "Îlots de fraîcheur urbains (2012)" to only display "Îlots de chaleurs urbains (2012)." The urban heat island zones appear in orange and in red. The "Légende" tab indicates that the colour orange corresponds to the "hot" zones and the colour red to the "very hot" zones. In addition to the urban heat island map, the canopy map and the data in the Géoportail of the Institut national de santé publique du Québec (INSPQ) can also be useful.

[7] In addition to the cartography of vulnerability to heatwaves, the data in the Géoportail of the INSPQ and the following sources of information can be useful: Évaluation de la vulnérabilité régionale aux changements climatiques, Facteurs de risque influençant la sensibilité à la chaleur and Les aléas affectés par les changements climatiques : effets sur la santé, vulnérabilités. What is more, it is strongly recommended to directly contact the local office of the public health branch of the territory of the municipal body or the Indigenous community, which can provide information on the vulnerability of the population to heat.

[8] Validated by the INSPQ.

Step 2. Identify, in a geographic information system, the location of infrastructure vulnerable to pluvial flooding. The vulnerability of infrastructure to pluvial flooding can depend on various factors, in particular their real or potential exposure to such phenomena. Other factors such as the presence of basements, the general condition of the infrastructure and the year in which it was built can affect vulnerability. Lastly, it is important to consider the role that the infrastructure plays, i.e., whether it provides essential public services or is of interest to the community. Generally speaking, it is important to consider homes, businesses, service infrastructure, schools, and healthcare establishments.

The information collected until now in the geographic information system will readily reveal whether the layers of geographic information collected in the preceding steps overlaps. The overlapping of layers will facilitate the identification of the zones with the highest level of risk. The next step will determine risk levels bearing in mind the overlapping of geographic information layers.

2. Risk assessment

At this stage, the following information has been collected:

- climate indices that provide an overview of changes in heat and heavy rainfall in the past, recent, and future climate;
- the location in a geographic information system of:
  - urban heat island zones;
  - zones that have sustained or risk sustaining pluvial flooding and the zone that drains water through subsurface drainage or subsurface drainage and contributes to flooding;
  - the populations vulnerable to heat;
  - infrastructure that is vulnerable to pluvial flooding.

To analyze the spatial distribution of risks in the territory, the risks must first be classified by means of the scales below (Table 2 and Table 3). **The risk level must be represented in the geographic information system by means of the classification by level and the colour legend below.**

Table 2: Heat-related risk matrix

Risk level		**Population vulnerability index**		
		Low to very low	**Moderate to average**	**High to very high**
Urban heat island	**Absence**	Nil or negligible	Low	Average
	Hot	Nil or negligible	Average	High
	Very hot	Nil or negligible	High	Very high

The response zones to be considered in the assessment are those in which a risk has been identified (low, average, high, very high).

Table 3: Risk matrix for heavy rainfall

Risk level		**Vulnerable infrastructure**		
		Absence	**Presence**	
			Provides essential services, is in the community's interest, or is a residence	
			No	**Yes**
Pluvial flooding risk zone	**No historical background or flood potential**	Nil or negligible	Low	Average
	No historical background but potential to create or sustain a pluvial flooding	Nil or negligible	Average	High
	Zone that has sustained a pluvial flooding or that has contributed to creating such a flood	Nil or negligible	High	Very high

The response zones to be considered in the risk assessment and in the subsequent planning of the response are those in which a risk has been identified (low, average, high, very high).

Once the risk level related to heat and heavy rainfall is represented in the geographic information system, **the risks must be cross-referenced in a matrix that facilitates the prioritization of initiatives** (Table 4). For example, if it has been determined that a zone (polygon) at very high risk in relation to heat islands overlaps a zone (polygon) at very high risk in relation to pluvial flooding, its intervention priority will be 1, i.e., the highest priority.

Table 4: Intervention priority matrix according to climate-related risks Level 1 corresponds to the highest intervention priority and level 5, to the lowest intervention priority when climate risks alone are considered

Intervention priority		Risk level related to heat islands				
		Nil or negligible	Low	Average	High	Very high
Risk level related to pluvial flooding	Nil or negligible	–	5	4	3	2
	Low	5	5	4	3	2
	Average	4	4	4	3	2
	High	3	3	3	3	2
	Very high	2	2	2	2	1

This matrix can be adjusted if the municipal body or the Indigenous community believes that it needs a higher level of precision.

The intervention priority should be given to zones with a combined risk level of 1, then of 2, and so on up to 5.

5. Climate change adaptation measures to be implemented: location and choice of green infrastructure

The risk level associated with heat and heavy rainfall determined in the preceding stage will guide the choice of preferred green infrastructure.[9] For example, if the risks related to heat are significant, large-growing trees can be favoured. In cases where risks related to heavy rainfall are more significant, valley gutters can be preferred. Demineralization simultaneously controls both risks.

The combined risk matrix, also produced in step 2, pinpointed the zones where combined risks related to heat and heavy rainfall are higher and thus where intervention is a priority.

Considering the intervention priorities established based on climate risks, **the type and location of the interventions planned must be indicated accurately in the geographic information system.**[10] Other relevant factors can guide the prioritization of initiatives, such as the possibility of taking advantage of the redevelopment of streets, the rebuilding of

[9] Under Component 2 of the program, the applicant must show that the green infrastructure that it plans to implement will be resilient faced with current and projected climate change impacts. For example, such resilience may lead to the choice of trees or plants that can prosper in the projected climate in the coming decades or with respect to which irrigation has been provided to face heat in the future climate, or by the resistance of green roofs to heavier winter loads.

[10] Data must be in an open format, e.g., shapefile or KML. It should be noted that the KML format is mandatory to submit a project under Component 2 of the OASIS Program.

infrastructure, the requalification of urban areas to establish adaptation solutions, the presence of partners willing act quickly, and so on.

The type and location of the green infrastructure chosen must reduce the risks related to heat and heavy rainfall (pluvial flooding) for populations and infrastructure.

To ensure that the establishment of green infrastructure has a genuine impact on ambient heat or damage to property and infrastructure stemming from heavy rainfall, it is necessary to plan the establishment of a sufficient density of green infrastructure in the zones affected by the risks.

At the conclusion of the risk analysis approach, the municipal body or the Indigenous community **must submit:**

- **the risk analysis document;**
- **a map with all the layers of geospatial information requested;**
- **an open data file that presents the priority intervention zones;**
- **an open data file that presents the location of green infrastructure;**
- **a list and a description of the green infrastructure selected and the justification for the type and location explained according to the risk levels.**

References

For information on populations that are vulnerable to heat and precipitation

Demers-Bouffard, D., 2021. Les aléas affectés par les changements climatiques : effets sur la santé, vulnérabilités et mesures d'adaptation, synthèse des connaissances.

Institut national de santé publique du Québec (INSPQ), undated. Mon climat, santé : Vagues de chaleur et santé humaine.

For information on stormwater management

Réseau Environnement, undated. Guide de gestion des eaux pluviales.

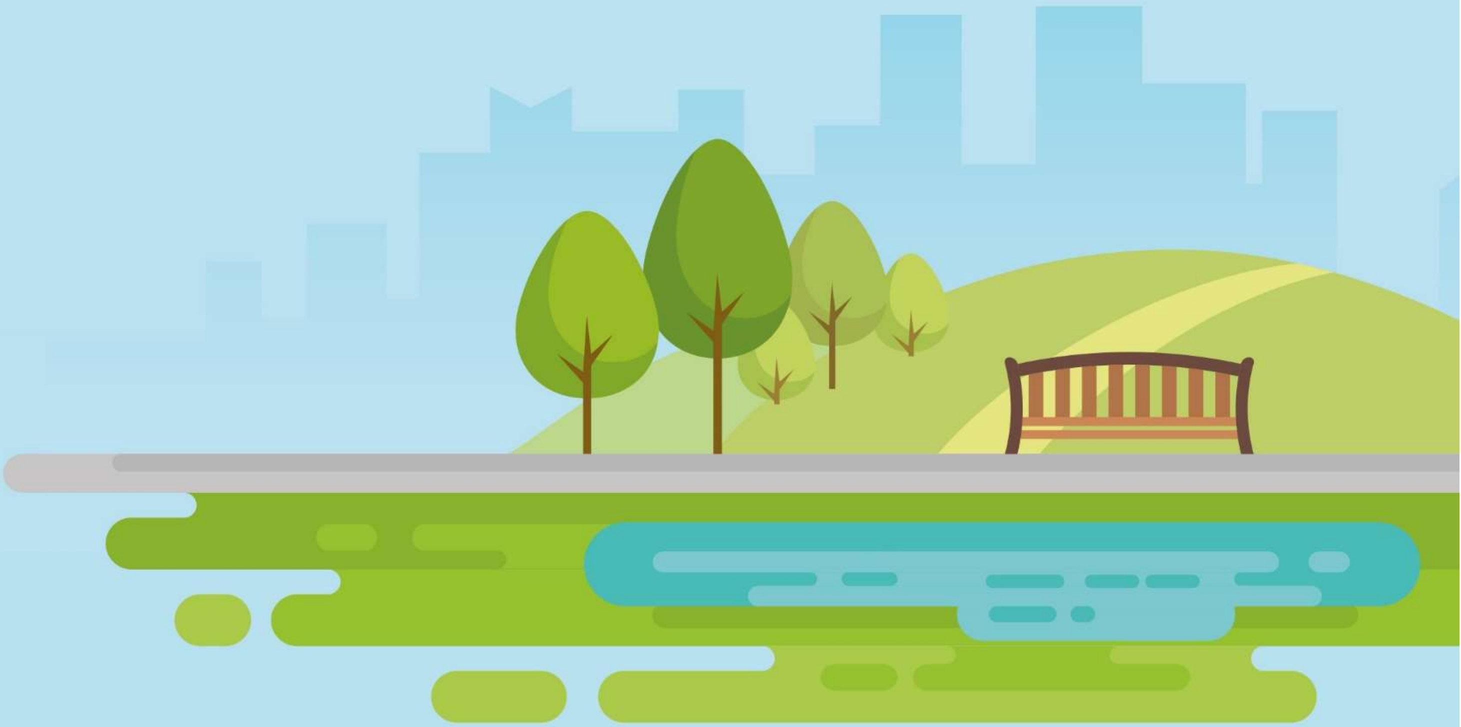
Mailhot, A., *et al*., 2014. Gestion des eaux pluviales et changements climatiques.

For information on climatic scenarios

Ouranos, 2016. Guide sur les scénarios climatiques.

For regional information on climate change

Ministère des Affaires municipales et de l'Habitation, undated Fiches synthèses régionales d'adaptation aux changements climatiques.



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