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PIEVC© FAMILY OF RESOURCES

» CATALOGUE «

A Guide for Selecting Climate Risk Assessment Methods, Data, and Supporting Materials

Published by the PIEVC Global Partnership:

Institute for Catastrophic Loss Reduction
Building resilient communities

CLIMATE RISK INSTITUTE

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In cooperation with:

Contents

KeyTerms

Vocabulary	Definition
Adaptation	Process of adjustment to actual or expected climate and its effects.
Adaptive Capacity	The ability of systems,institutions,humans and other organisms to adjust to potential damage,to take advantage of opportunities, or to respond to consequences.
Climate Hazard	Specific impactful event as related to the broader climate parameter category.
Climate Hazard Indicator	Specific climate values (TMax > 35C; Precip > 100mm; Freezing Rain > 30 mm, etc.) that are defined by their ability to impact an infrastructure system or component (i.e., exceed a threshold).
Climate Parameter	Broader categories of measurable climate conditions in relation to which specific climate hazards or indicators can be defined. Climate parameters include temperature, precipitation, sea-level rise, wind, etc.
Components	Physical elements or features of a composite system.
Consequence	Outcome of an event affecting objectives.
Decision-Maker	The person or group of individuals who is responsible for making strategically important decisions based on a number of variables, including time constraints, resources available, the amount and type of information available and the number of stakeholders involved.
Element	A distinct part of a composite system. Could include physical, planning or human resources.
Exposure	The presence of people,livelihoods, species or ecosystems, environmental functions, services,resources,infrastructure,or economic, social or cultural assets in places and settings that could be affected.
Likelihood	Chance of something occurring; within the context of climate risk assessment, the chance of a defined climate hazard over a given time horizon.
Portfolio	A collection of assets or policies that are characterized by different risks.
Probability	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty.
Residual Risk	Risk remaining after risk treatment.
Resilience	The capacity to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure.
Risk	Effect of uncertainty on objectives.
Risk Appetite	Amount and type of risk that an organization is willing to pursue or retain.
Risk Tolerance	Readiness to bear the risk after risk treatment.
Risk Treatment	Process to modify risk.
Threshold	Point beyond which a system, because of physical damage or failure, is deemed to be no longer effective or safe: economically; socially; technologically; physically; or environmentally. Also known as tipping point.
Triple Bottom Line (TBL)	A business concept that states organizations should commit to measuring their social, environmental impact, and financial performance—rather than solely focusing on generating profit.
Vulnerability	Propensity or predisposition to be adversely affected.

A Living Document

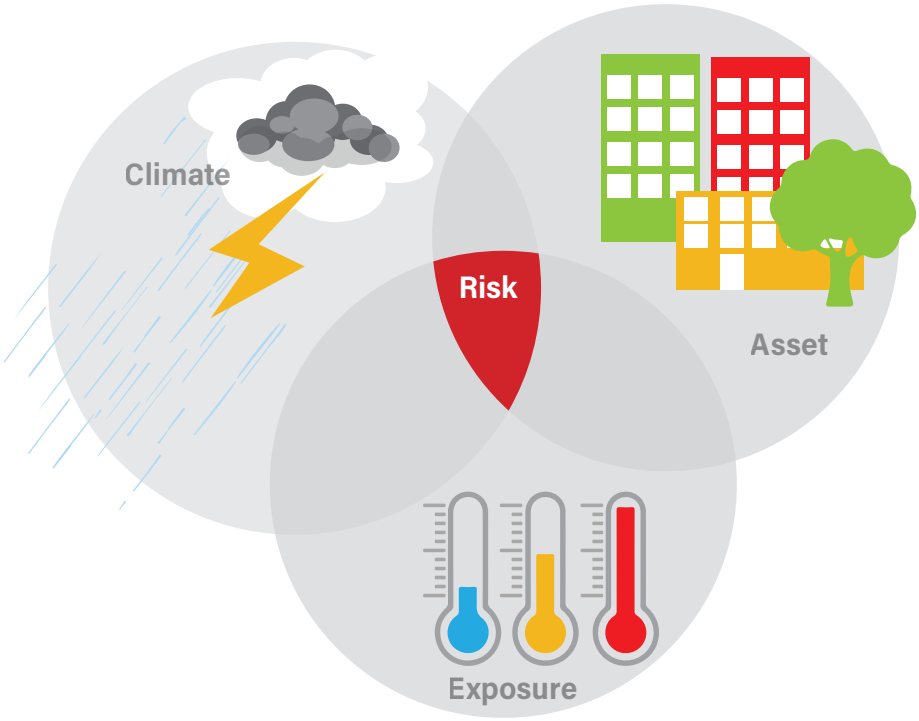
Climate change work is in a period of rapid change. This Catalogue reflects the most recent knowledge about climate resilience work. It summarizes the latest thinking about how users may use PIEVC to assess climate risk and develop effective actions.

As this Catalogue evolves, new knowledge, information and other factors may develop that are not covered in the current document. This Catalogue as a living document. As it develops, it will incorporate the latest ideas, concepts, resources, and examples.

In this Catalogue, you will find boxes where you can add your examples to add to then Knowledge about climate resilience. Your suggestions will help other users produce meaningful and practical adaptation action. Your ideas may be included in future revisions of this document and will help PIEVC develop new tools to support this work.

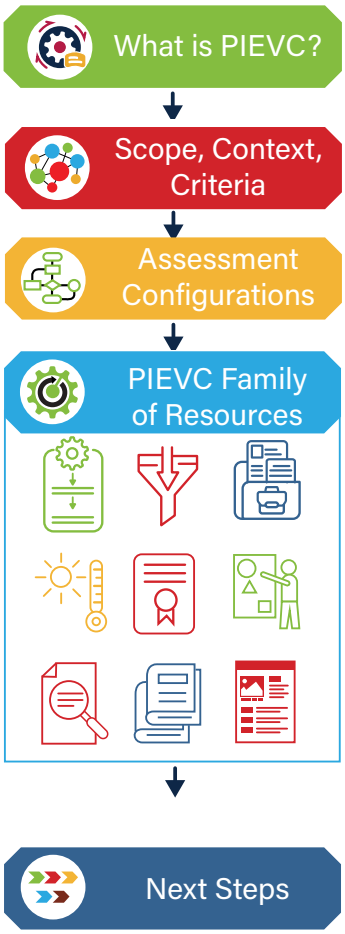
Consult with the Experts

This Catalogue is a high-level planning document. It does not delve deeply into the various areas of expertise often necessary for skilled execution of climate assessment work. Each of the cited resources focuses more deeply on these skill sets and the experts and stakeholders typically necessary to support successful work. Parties are encouraged to consult with appropriate experts when planning their work. This Catalogue offers guidance on the resources that are available to support climate resilience work. Each project will require appropriate staffing and resourcing.



Catalogue Roadmap

This Catalogue is designed to help decision-makers navigate through the different considerations and options for assessing climate change risk and resiliency using the PIEVC family of resources. The catalogue guides the users through the objective-setting process and based on their objectives, helps them choose the optimum assessment paths and tools.

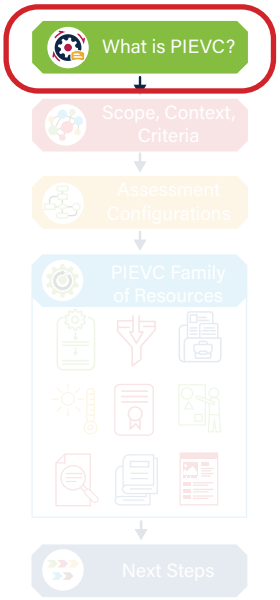


The catalogue is highly interactive. Users may navigate through the document by clicking on hyperlinks, liberally placed throughout the document. The Catalogue Roadmap establishes the pathway through the document and serves as a home- base within the document framework. Each panel of the roadmap is linked to relevant sections of the Catalogue. Users may return to the roadmap by clicking on "Back" buttons located within each section of the document.

The Catalogue highlights the five core concepts necessary to establish a climate risk and resiliency assessment objectives, select an assessment pathway, and ultimately establish follow-up activities in the roadmap. It is designed to allow users to choose their path through the process, and provides links to additional resources, training, and tools along the way. The roadmap serves as a home base to allow users to reset and choose alternative paths they may deem appropriate to their own unique need

What is PIEVC?

In 2005, Engineers Canada established a national committee called the Public Infrastructure Engineering Vulnerability Committee (PIEVC) to oversee development and delivery of a Protocol for the evaluation of risks related to the impacts of climate change on physical infrastructure in Canada. The PIEVC Protocol has been used in over 100 assessments of various types of individual infrastructure, larger infrastructure systems, and infrastructure portfolios. The PIEVC Protocol describes a step-by-step method of risk assessment and optional engineering analysis for evaluating the impact of changing climate on infrastructure. The observations, conclusions and recommendations derived from the application of the PIEVC Protocol provide a framework to support effective decision-making.



Applications of PIEVC

PIEVC is based on standard risk assessment methods. It may be used to conduct climate risk and resiliency assessments to support a range of applications, including:

- Asset management, capital, and master planning
- Infrastructure operations and management evaluation and review
- Asset portfolio assessment and evaluation
- Concept and preliminary engineering design
- Green and natural infrastructure assessments
- Firms starting to report on climate risks as part of a Carbon Disclosure Project or other financial requirement
- Applications requiring standard risk assessment methodologies compliant with ISO 31000 and ISO 14090

Back

The PIEVC Family of Resources

PIEVC Protocol

The PIEVC Protocol outlines a process to assess infrastructure responses to changing climate. Information developed through the assessment process helps owners and operators incorporate adaptation into design, development, and management of existing and planned infrastructure.

Read More …

High Level Screening

The PIEVC HLSG is designed to help infrastructure owners gain a high-level assessment of the potential risks posed by climate change to their infrastructure and related elements. Generally, the distinction between the PIEVC HLSG and the PIEVC Protocol is the level of detail pursued at each step.

Read More …

Portfolio Screening

The PIEVC Portfolio Screening Manual details general approaches to use the PIEVC Process (PIEVC Protocol, PIEVC High Level Screening Guide) on a Portfolio of assets. PIEVC assessment of a portfolio follows the same principles used in a single-asset assessment for multiple assets.

Read More …

Climate Guidance

The primary goal of the PIEVC Scoping and Data Collection Tool (SDCT) is to increase the efficiency of PIEVC applications by providing a better, guided, and structured way to understand and communicate climate information requirements and capture and organize climate information for risk assessment (scoring) purposes.

Read More …

Certification

The Infrastructure Resilience Professional (IRP) Program has been designed to help infrastructure practitioners strengthen the knowledge and competencies they require to advance more climate-resilient approaches for the planning, design, and management of infrastructure.

Read More …

Assessment Reports

The Institute for Catastrophic Loss Reduction maintains a detailed listing of previous PIEVC Assessment reports. These are available to anybody who wishes to see how successful PIEVC assessments have been conducted., and to draw on the reporting formats, experience, and expertise of other practitioners.

Read More …

International Studies

PIEVC has been used widely around the world. It has generated good results not only in Canada, but worldwide. The principles of risk, vulnerability, and climate analysis are flexible. So, PIEVC can support the needs of a wide range of studies, from small local work to large assessments of national-level portfolios.

Read More …

Community of Practice

Risk assessment can be complex. It may require skills of a variety of experts. These may include risk management, climate data development, asset management, policy, planning, infrastructure design and operation, environmental, and others, depending on the project. Parties planning projects may wish to consult experts. But where do they find these experts?

Read More …

Associated Secondary Documents

Besides assessments, the PIEVC community has also taken part in a range of supporting climate work. This work shows what others have done. It gives a good starting point and may head off work that reproduces the efforts of others.

Read More …

Other Useful Resources

ISO 31000 – Risk Management Guidelines

ISO 31000 is an international standard that describes principles and guidelines for effective risk management. It illustrates a general approach to risk management that apply to many types of risk. It may be used by any type of organization.

ISO 31000 is a member of a larger family of risk management standards, including **ISO 31010 and ISO Guide 73**. These standards may used broadly, across various industries, niches, and business types. As a whole, the **ISO 31000** family of standards outline best practice and guidance to all operations wishing to use the principles of risk management.

ISO 31000 does not offer detailed instructions or requirements on how to manage specific risks. Rather, it describes the fundamental principles of risk management. The supporting standard, **ISO 31010**, provides more detail on specific risk assessment approaches and where those approaches may be best used.

Tie-In with PIEVC

The PIEVC Family of Resources align with **ISO 31000** principles. **ISO 31000 i**s a useful resource for PIEVC users wishing to gain a deeper understanding of the general risk principles that underlie PIEVC's basic processes.

Learn more about ISO 31000

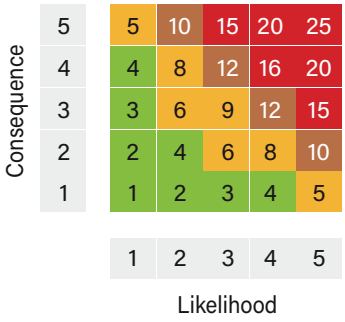
ISO 31010 – Risk Assessment Techniques

31010 ISO

ISO 31010 describes a range of methods to improve the way uncertainty is considered and to help understand risk. The techniques may be used to:

- Better understand what risk exists or characterize a particular risk
- Compare or optimize a range of options involving risk
- Support a risk management process aimed to identify risk treatment options

ISO 31010 offers a summary of methods and compares their uses, benefits, and limitations. It also provides references to more detailed information. The techniques can be used in a wide range of settings. Users may apply the techniques within the risk assessment steps of **ISO 31000**, and generally whenever they need to better understand uncertainty.



Tie-In with PIEVC

The PIEVC Process aligns with **ISO 31010 Method 10.3 Consequence / Likelihood Matrices**. PIEVC users may find the foundational guidance offered by **ISO 31010** useful in providing a deeper understanding of the approaches generally used within PIEVC. **ISO 31010** identifies a wide range of other risk assessment methods that may support and enhance a PIEVC assessment. The standard is available for purchase directly from ISO.

Learn more about ISO 31010

ISO 14090 – Adaptation Principles

ISO 14090 is an international standard that helps users prepare effective adaptation plans. It outlines a robust way to reduce the harm from climate change and take advantage of opportunities. It works for any organization of any size and helps them reinforce adaptation in day-to-day work. Following the standard allows users to develop and report on adaptation plans.

ISO 14090 covers:

- Pre-planning
- Assessing impacts and opportunities
- Adaptation planning
- Implementation
- Monitoring and evaluation
- Reporting and communication

Tie-In with PIEVC

The PIEVC family of resources fits within the framework established by **ISO 14090.** **ISO 14090** aligns with **ISO 31000**. It establishes a climate change risk management process that uses concepts firmly established in the **ISO 31000** standards. Users may use **ISO 14090** to set up their adaptation planning framework and apply PIEVC resources to complete the climate risk assessments that support the program.

The standard is available for purchase directly from ISO.

Learn more about ISO 14090

ISO 14091- Vulnerability, Impacts and Risk Assessment

ISO 14091 provides guidance on climate change risk assessment. It describes vulnerability and how to implement a risk assessment. It can be used for both present and future climate change risk.

Risk assessment provides a basis for adaptation planning for any organization of any size and type.

ISO 14091 is a guide to the use of screening level assessments and impact chains. The risk screening may be a stand-alone, simplified risk assessment or a lead-in to impact chain analysis. Both screening level and impact chain assessments allow qualitative and quantitative analysis.

Tie-In with PIEVC

ISO 14091 outlines the fundamentals of a climate risk assessment procedure very similar to PIEVC, but the standard does not provide the step-by-step guidance offered by PIEVC. **ISO 14091** provides a solid reference for climate risk assessment that can help users delve more deeply into the processes outlined by PIEVC. It can serve as a very useful guide for setting up a PIEVC assessment.

The standard is available for purchase directly from ISO.

Learn more about ISO 14091

ISO 14092 – Adaptation Planning

14092 ISO

ISO 14092 describes how to develop an adaptation plan at the local level. It supports setting priorities and the preparation of useful plans. **ISO 14092** gives direction on preparing for climate change. It recognizes the effects of climate change vary widely across regions, communities, and local governments.

ISO 14092 details setting up governance systems, planning, and execution. The plan may be aligned with local climate, environmental, and social conditions.

Tie-In with PIEVC

PIEVC assessments often are used as a base for adaptation planning. However, PIEVC is a risk assessment process that does not offer guidance on how to design and implement those adaptation plans. **ISO 14092** fills this gap and used with PIEVC, allows users to characterize their climate risks and establish workable adaptation plans.

The standard is available for purchase directly from ISO.

Learn more about ISO 14092

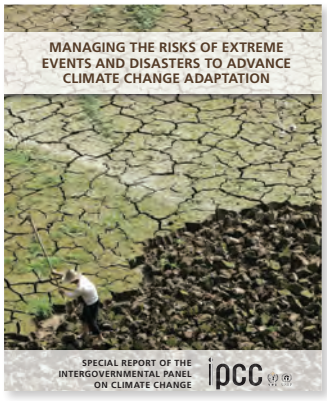
IPCC

The Intergovernmental Panel on Climate Change (IPCC) is a United Nations group that discusses climate science. Its scientists look at the ongoing effects and future risks of climate change. They offer ways to reduce the damage and adapt to climate change.

The IPCC produces major reports every few years. These are offered in a non-technical style for a wide audience.

The IPCC selects hundreds of scientists from across the world to produce the reports based on peer-reviewed literature. The IPCC considers thousands of studies when developing their reports on climate change.

Tie-In with PIEVC



PIEVC assessments are aimed at reducing climate change risk. IPCC are experts on climate change. Their work can be useful to establish a framework within which to conduct the PIEVC work. Users can find national greenhouse gas inventories, the latest climate projections, and many other reports and analyses to support PIEVC assessments.

Of note is a major report on climate risk, issued by IPCC in 2012 - **Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation**. This report presents a thorough review of climate risk and provides a grounding for PIEVC assessments.

Other IPCC resources are available for download.

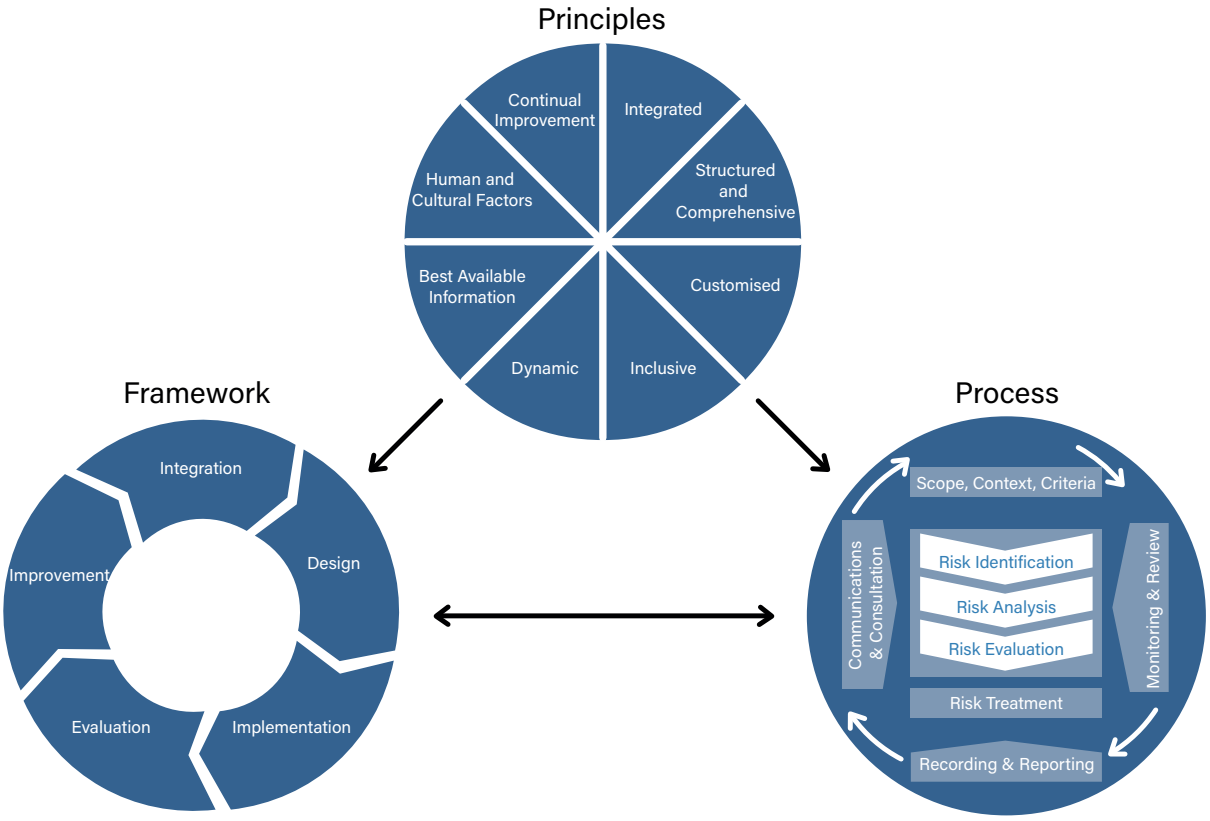
IPCC Risk Report

Other IPCC Resources

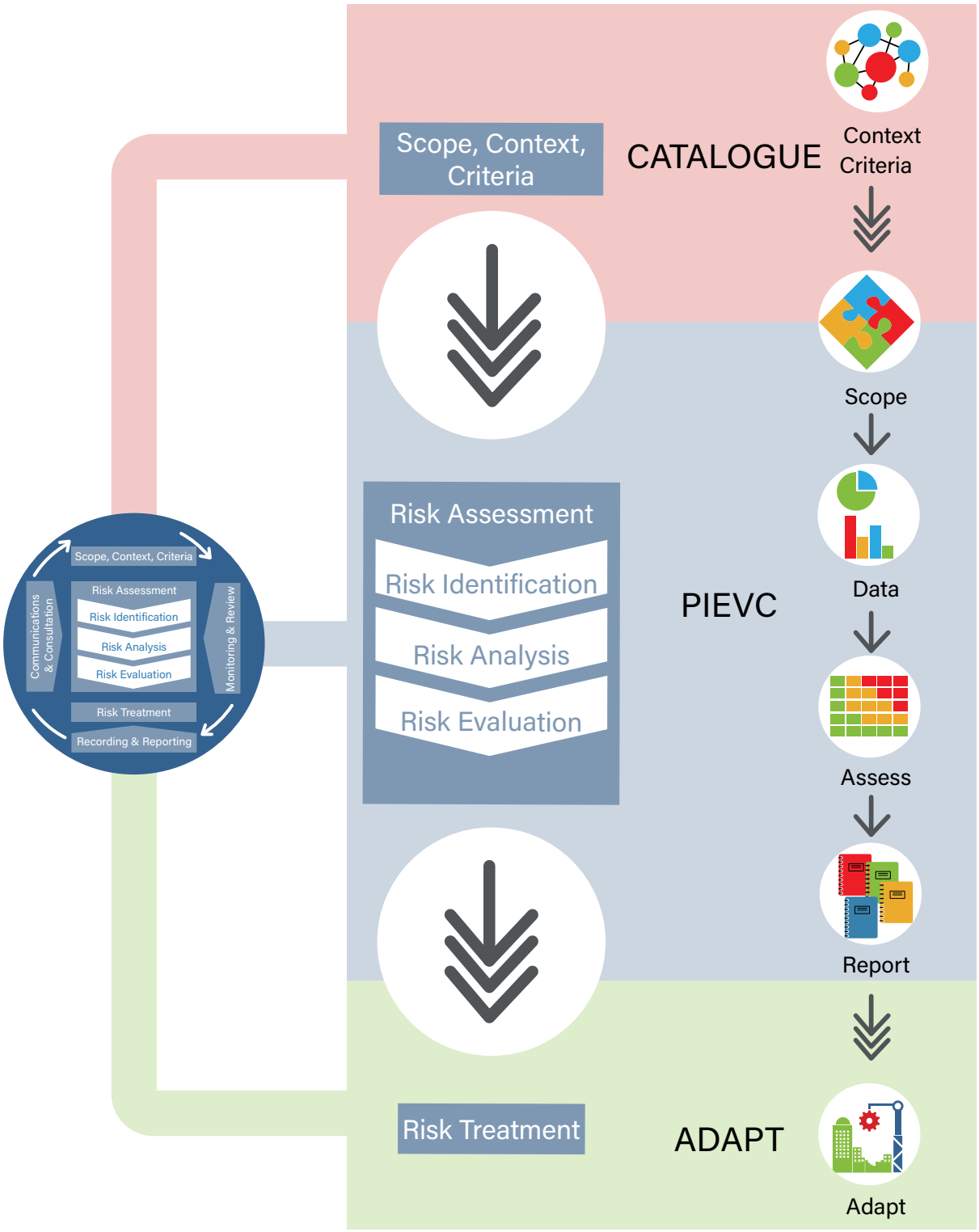
Where Assessment Fits in the Process

ISO 31000 lays out a comprehensive risk management process. Only one key part of the process involves risk assessment. **ISO 31010** provides additional guidance on the various risk assessment methods that are best suited to the ISO risk management process.

Climate change poses a special case that users must blend into the wide range of risks they already manage. Climate change adds additional challenges in the way we blend climate information into the assessment. The PIEVC family of resources was developed specifically to address these issues. They align with the ISO risk management process.



PIEVC does not provide guidance on the Principles and Framework pieces of ISO. It picks up at the Scope, Context, Criteria stage of the risk management system. PIEVC sets objectives based on the risk management principles of the host organization. The PIEVC assessment must align with this foundational work. Hence, PIEVC emphasizes consultation to ensure that there is a good agreement between the assessment and risk management system.


Scope, Context, Criteria
CATALOGUE
Context Criteria
Scope
Data
Assess
Report
Risk Assessment
Risk Identification
Risk Analysis
Risk Evaluation
PIEVC
Risk Treatment
ADAPT
Adapt
Scope, Context, Criteria
Risk Assessment
Risk Identification
Risk Analysis
Risk Evaluation
Risk Treatment
Recording & Reporting
Communications & Consultation
Monitoring & Review

Sometimes, host organizations do not have a formal risk management system. They may manage risk on ad hoc basis. In these cases, PIEVC may bring vital information to help establish a risk management program.

PIEVC may offer treatment alternatives. However, often it doesn't yield enough detail to support action. PIEVC sets risk priorities. While there may be overlap between PIEVC and treatment plans, more often alternatives must be checked further. For example, often PIEVC spots a case needing engineering. The engineering team may find other, more efficient approaches.

While PIEVC paves the way for action, only a working risk management system guarantees success. PIEVC is only one part of a successful approach. PIEVC fits into a broader risk management system.

What Assessments Can Do

Assessments are very good at spotting and prioritizing risk. They itemize which parts of a system are more at risk and provide context to decision-makers on where to put risk treatment efforts.

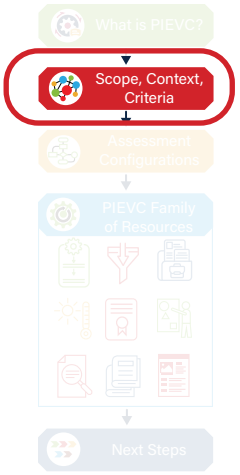
What Assessments Cannot Do

Usually, risk assessments do not generate a complete picture of risk treatment options. They can offer insight on preliminary treatment options and a list of steps that may be examined later. Often, teams do not have the skills or time to work out fulsome treatment options. So, they can describe who and where to go for further work and offer opinion on some plausible options. Final treatment options call for work by relevant professionals.

Back

Scope, Context, and Criteria

What are the Objectives?



Every assessment starts with establishing objectives, which are based on the project's scope, context, and criteria. From there, users can sort out the correct level of detail, appropriate climate information and portfolio assessment considerations. In some cases, the project proponent will also need to develop a deeper level of understanding of the basic PIEVC Processes. To support this guide offers direction to training offerings, historical PIEVC reports and case studies that may inform the overall assessment process.

Common assessment objectives may include:

- Identify highest risk assets to climate change
- Identify common climate risks between common infrastructure elements
- Identify common climate risks different climate regions
- Screening risk for managing an asset Portfolio
- Risk assessment as part of a regulatory process or funding process
- Due diligence in managing and governance of assets, reporting
- Planning for proposed Infrastructure
- Identifying risks of similar (archetype) infrastructure
- Capacity building on climate change risk and adaptation in an organization

Back

The objectives of the assessment will dictate its complexity, the time to complete it, the resources, and data to complete an assessment. The objective of the assessment will guide the process, and when in doubt, assessors should refer to the stated objectives to protect against scope creep.

What is the Scope?

The scope identifies key details and questions that should be addressed by the work. As a minimum, the scope should assign the boundaries for the assessment both physically and in time. The scope will provide information on where and what is being assessed, and over what timeframe.

The owner should give clear direction about the purpose of the work. The scope will normally identify key stakeholders who may be consulted, or even included, on the team.

Assessors should clearly understand the objectives. PIEVC provides guidance on seeking this sort of guidance as one of the main tasks during the early stages of work. Owners should have a clear picture of their objectives to provide the team with clear boundaries, focus, and expected results. These scoping considerations inform the level of complexity of the assessment and the selection of tools and resources for the work.

ISO 31000 and **14090** offer guidance on establishing project scopes.

Useful Resources:

31000 ISO

14090 ISO

What is the Context?

Each project should establish if the work is looking more inward or outward. Is the focus on systems and assets under the direct control of the owner? Or is the focus on effects on other parties, or even broad social impacts? This defines the external and internal context of the work.

Context flows from the scope and helps define the project boundaries. This provides a clearer definition of the objectives of the work.

Users may use a blended approach, looking at both the internal and external context. They must consider how much weight to place on the internal and external factors to provide explicit objectives, setting the boundaries of the work.

Context must mirror the objectives and activities of the owner. When selecting assessment tools, the user must consider if the work is focusing more inward or outward. Work runs more smoothly when the context is clearly detailed before starting work.

ISO 31000 and 14090 offer guidance on establishing the context of an assessment.

Useful Resources:

31000 ISO

14090 ISO

What are the Criteria?

Every entity should identify the amount and type of risk that they are willing to take. This is, this is called **risk appetite**. It determines the overall risk the entity can accept. When doing assessments, care must be taken to align the work with these criteria.

The definition of risk appetite should support the values, objectives, and resources of the owner. They also need to be consistent with the owner's policies and statements about their risk management programs. The criteria should also consider the views of its key stakeholders.

Normally, criteria are determined at the beginning of an assessment process. However, assessment is dynamic, and often the team will review and amend criteria as work progresses. When the work is underway, the team may find conditions not considered when creating the original criteria. Adjusting is a normal and accepted practice in assessment.

When establishing the criteria, the user should establish how consequences and likelihood will be defined and measured, the organization's capacity to respond to risk, resources the organization is willing to put into addressing identified risks and the residual risk the organization is willing to tolerate at the end of the process. Tolerance will define the budget and effort to manage identified risks.

ISO 31000 and 14090 offer guidance on establishing the context of an assessment.

Useful Resources:

31000 ISO

14090 ISO

Is it a Single Asset or Portfolio?

PIEVC may be applied to single infrastructure assets or to sets of multiple assets, called "portfolios."

An example of a single asset assessment is the assessment of an individual bridge.

A portfolio is a set of assets owned, operated, or regulated by a single organization. The "single organization" constraint aligns the assessment with the objectives, risk tolerance, and risk appetite of one centrally responsible entity, and manager of risk.

Many portfolios considered in PIEVC work are owned, operated, or regulated by government organizations. However, many private companies also own or operate asset portfolios.

PIEVC portfolio assessments follow the same general principles used in single asset assessments, though certain steps require additional considerations.

Useful Resource:

Similar Assets in Many Locations

One Location with Many Assets

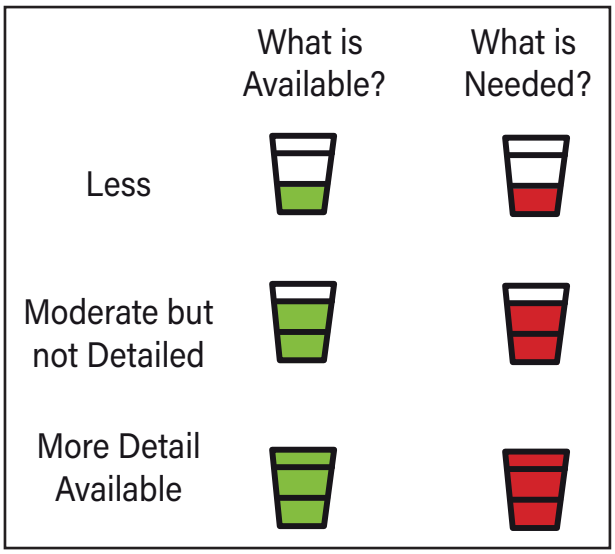
One Linear System Crossing Multiple Climate Zones

Many Locations with Many Assets

What Level of Detail is Necessary?

Precision vs Accuracy

When planning a climate risk assessment, users must consider the level of detail necessary to support the work. Detail falls into two categories. First, the data that is available. Second, the data needed to run an efficient assessment.



Users may wish to have more data, more precision, or more depth than available. Often, data with less detail can yield suitable results. This is especially the case when doing screening level assessments first, and more detailed assessment on critical elements later. The later work can be more focused, have tighter scope, and use a smaller array of detailed data. As the work is more focused, the result is a reduction in effort and cost. Developing new, highly detailed data sets can be expensive.

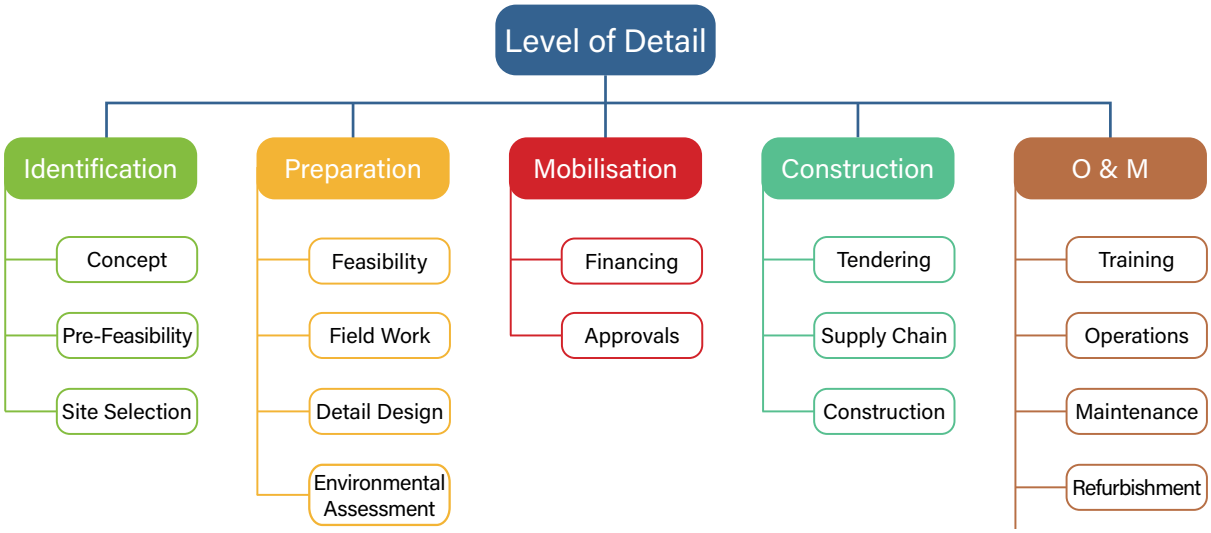
Users must be careful to not confuse precision and accuracy. In all cases, users should use the best data available, but that does not mean that the data must be very fine. Sometimes, high-level proxy data is as useful, or more useful than complicated data sets. Often, it is better to be generally accurate than precisely wrong.

This section examines the level of detail needed for climate risk work at different times of a project's life. It considers the data usually available at each stage, and the data needed for climate work usually done in that phase.

Sometimes, climate risk work does not demand all the data that may be available. It is more efficient, in the longer term, to conduct screening studies, prior to doing detailed risk assessment work. This allows for quicker assessment, less overall effort and expense, and alignment between objectives and data demands.

Stage of Lifecycle

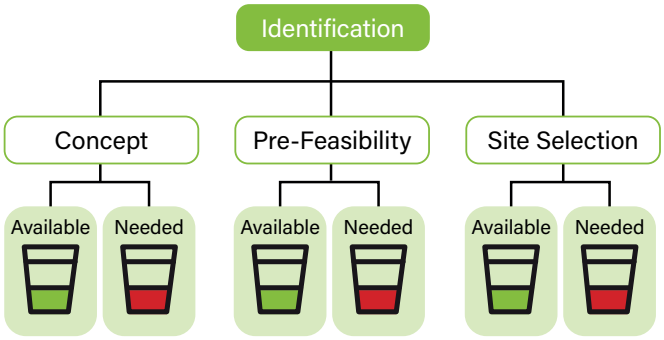
Where a project is in its overall lifecycle can affect the amount of information available to conduct an assessment . Generally, the more mature the project is the more depth of data available to the project team.



Caution must be taken to not fall into the trap of letting the amount of available information drive the complexity of the assessment. For example, while it is possible to conduct a fully comprehensive PIEVC assessment of a freshly designed and commissioned system, it may be a better strategy to conduct a PIEVC High-Level Assessment first to triage the system and focus on critical areas. Thus, for the preliminary work the assessment may apply only the **High-Level Screening Guide** on a wider array of infrastructure elements. Then as a second pass, the assessment could employ one of the more comprehensive assessment pathways on key system elements identified through the screening. This would demand the use of PIEVC Protocol, or some other comprehensive risk assessment methodology.

Identification

The Identification phase of a project generally focuses on scoping, pre- feasibility, concept, site selection, and preliminary costing of likely projects. At this stage, there is no detailed design, and the project may not have funding approval.



The level of data detail available is generally low, concept information sufficient to generate preliminary cost estimates and for discussion with decision makers.

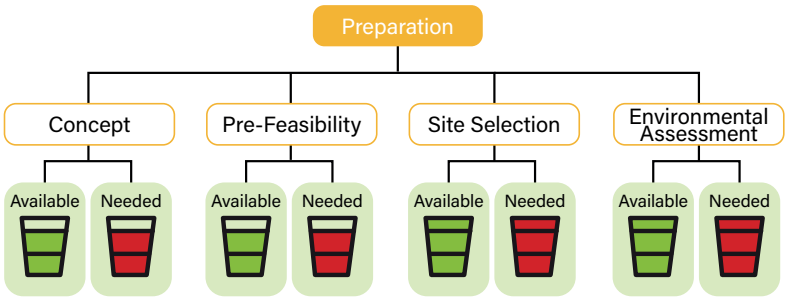
At the Identification stage, climate work may be needed to aid the project concept and funding support. Detailed data is not typically required. The level of climate assessment detail must align with the level of detail in the conceptual design. In this way, there's good alignment between the data that it's available and the data that is needed for climate work. At this stage, highly detailed climate information may be expensive, and spending time and budget on developing such data may be unfruitful. Rather, work would normally focus on proxy data and analysis. This would direct users to high-level screen work as outlined in the High-Level Screening Guide.

Useful PIEVC Resources:

HLSG

Preparation

During the Preparation Phase, the project is progressing. Fieldwork is underway, feasibility studies are being conducted, detailed design is in progress, and costing is being developed. Often, environmental impact assessments are required. The level of detail is significantly more demanding than in the Identification phase.



During feasibility and field work, the level of data that is available is generally at moderate levels, and the level of data required for climate work aligns. For detailed design, more robust data sets are being developed and more robust data is available. Finally, in the environmental assessment stage, regulators will often demand high levels of detail to assist in reviewing the project and providing approvals.

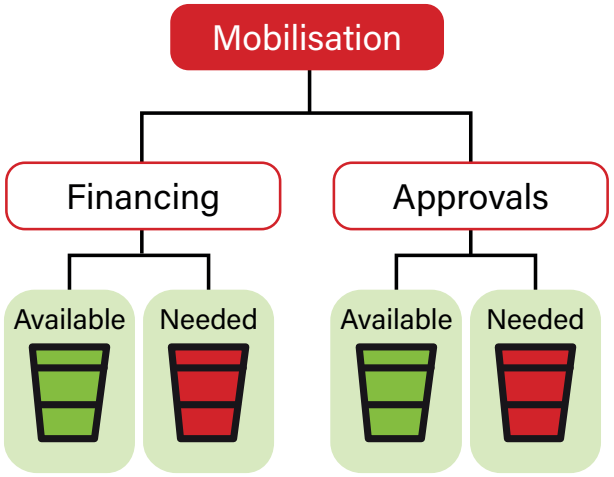
These levels of detail generally lead to a deeper assessment process, such as that outlined in the PIEVC Protocol. The High-Level Screening Guide may also support this work, but the level of data used for the analysis must be tailored to support the more precise demands of this phase of the project.

Useful PIEVC Resources:

HLSG Protocol

Resource Mobilization

In the Resource Mobilization phase, projects are seeking funding and approval. This typically calls for high levels of detail. Sometimes, funders or regulators will require specific assessment methods or levels of precision. In these cases, assessments must be conducted according to the funder or regulator's requirements. This will drive the level of detail for the assessment. Funders and regulators want to have a precise understanding of the project. Fortunately, the design is complete and high levels of data detail are available.



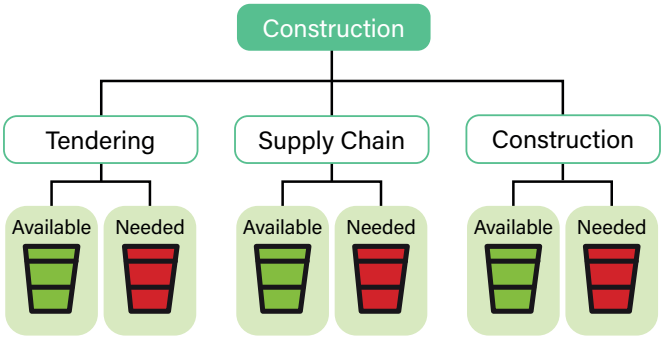
This supports the use of the **PIEVC Protocol**. Work may also be conducted using the **High-Level Screening Guide**, but the level of data used for the analysis must be tailored to support the more precise demands of this phase of the project.

Useful PIEVC Resources:

Protocol HLSG

Implementation & Construction

The Implementation and Construction phase of the project generally requires high levels of detail. At this stage, the project is tendering, construction is underway, and manuals and guidance are being prepared. Rigorous training may be required to support start-up and early operation of the project.



A lot of data detail is available because the design is done. Climate work done at this stage will require supporting or aligning with these high levels of detail.

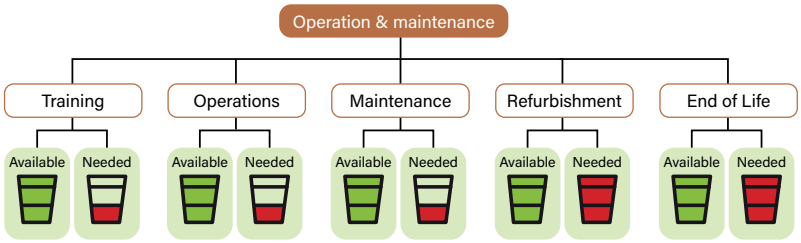
This supports the use of the **PIEVC Protocol**. Work may also be conducted using the High-Level Screening Guide, but the level of data used for the analysis must be tailored to support the more precise demands of this phase of the project.

Useful PIEVC Resources:

Protocol HLSG

Operation & Maintenance

The Operation and Maintenance phase covers five key activities: the operation of the project, maintenance, refurbishment, and ultimately the end of useful life and retirement of the project.



During training, operations, and maintenance, a lot of data may be available. However, detailed data may not be necessary. There is significantly more data available than may be needed to do climate work. Care must be taken to guard against overdoing the assessment. This work generally requires a simple proxy analysis, or high-level screening to determine where additional effort might be required.

During refurbishment and end-of-life stages, however, significant levels of engineering and tendering may be required. The detailed data that is available will be needed data to support the needed climate work. These activities are like the design and construction phase. Detailed information is both necessary and available.

The level of necessary detail in the training, operations and maintenance support using the **High-Level Screening Guide**. However, refurbishment and end-of-life work may require the **PIEVC Protocol**, the **High-Level Screening Guide**, with the level of data tailored to support the more precise demands of this phase of the project.

Useful PIEVC Resources:

Protocol HLSG

Your Examples:

Often teams will encounter unique issues that previous PIEVC work may not have identified. These examples can inform and improve the ongoing development of the PIEVC family of resources. If you wish to share your experience, your input is welcome.

Your Examples

Useful Resources:

31000 ISO

14090 ISO

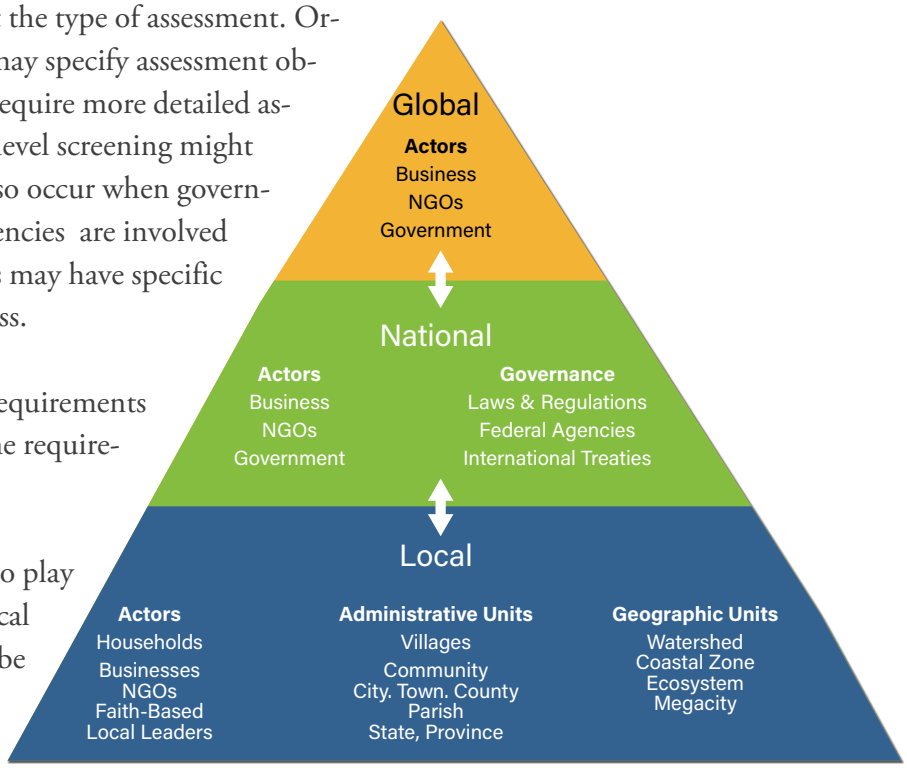
Back

Are there Jurisdictional Concerns?

Jurisdictional factors may affect the type of assessment. Organizations that fund projects may specify assessment objectives. Sometimes, they may require more detailed assessments at stages where high-level screening might otherwise suffice. This could also occur when government or inter-governmental agencies are involved in projects. These organizations may have specific needs that the team must address.

Teams must understand these requirements and tailor their assessment to the requirements of these agencies.

Other parties that can come into play include global, national, and local administrations. Teams should be sensitive to these stakeholders and respect their needs when choosing the tools for their climate work.



Global

Globally, these may include international businesses, non-governmental organizations (NGOs), and governments.

Examples: Large multi-national businesses, global NGOs such as Greenpeace, national governments, and international bodies, such as the IPCC, WHO, and the World Bank.

National

Nationally, this may include national businesses, non-governmental organizations, and governments. Considerations could include laws and regulations and other national commitments.

Examples: Large businesses with interests throughout a country, NGOs such as national branches of Greenpeace, national, and regional governments.

Local

Locally, non-governmental agencies might have a role to play. Households, local businesses, faith communities, and local leadership might impact assessment requirements, which could affect the selection of tools and resources.

Examples: Local businesses, community organizations, local NGOs, religious groups, regional, and local governments.

Inter-jurisdictional Examples

Users may also have to consider other inter-jurisdictional concerns. The user may have to use specifically tailored tools to address concerns that might otherwise be apparent. This could temper the sort of assessment conducted, and the tools from the PIEVC family of resources that the user accesses.

Examples: Watersheds, coastal zones, ecosystems, and megacities could affect more than one jurisdiction, each with its own set of requirements.

A roadway owned and operated by a regional government that runs through communities intersecting with local roads and affecting local businesses and residents.

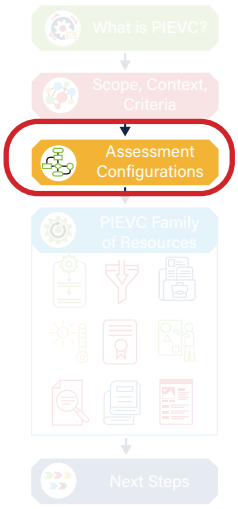
Your Examples:

Often teams will encounter unique issues that previous PIEVC work may not have identified. These examples can inform and improve the ongoing development of the PIEVC family of resources. If you wish to share your experience, your input is welcome.

Useful Resources:

PIEVC Assessment Pathways

The assessment configuration is established through a combination of jurisdictional requirements and project objectives. The level of detail of a particular assessment can vary depending on these two integrated factors.



A PIEVC climate risk assessment may follow one of five different pathways, each tailored to the objectives and jurisdictional requirements driving the work. These include:

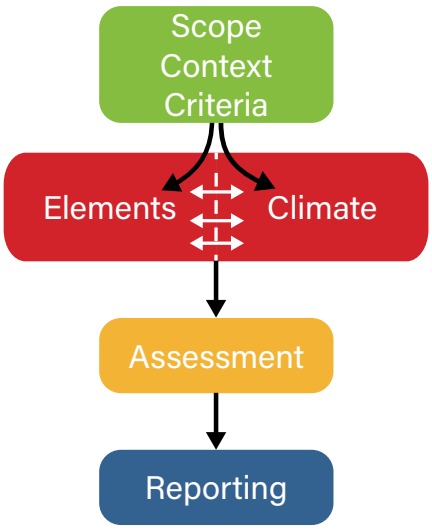
1. The Basic Process
2. The Basic Process + Engineering Analysis
3. The Basic Process + Triple Bottom Line Analysis
4. The Basic Process + Engineering Analysis + Triple Bottom Line Analysis
5. The Basic Process + External Analysis

The following sections provide further detail on these pathways and offer suggestions on useful PIEVC and other resources that can be accessed to support the work.

Back

Basic Process

Typical Applications: Four basic steps are common to all PIEVC assessments. These include scoping context and criteria for the assessment, definition of infrastructure elements and climate parameters, the assessment process itself, and reporting. This process can be used for both high level and detailed climate risk assessment. Guidance on detailed climate risk assessment is found in the **PIEVC Protocol**. Users may also apply the **High-Level Screening Guide** to do screening level assessment, or detailed work if data is tailored to suit.



While the basic process is common to all PIEVC pathways, the level of detail, precision, and objectives of the work will vary. These differences drive the PIEVC resources used to guide the work.

Useful PIEVC Resources:

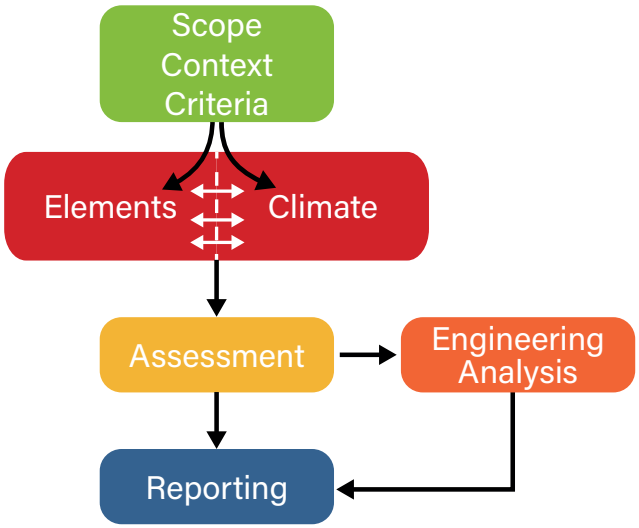
Protocol HLSG

Other Useful Resources:

31000 ISO 14091 ISO

Basic Process + Engineering Analysis

Typical Applications: The basic process plus engineering analysis is described in the PIEVC Protocol. In this process, specific parts of the analysis are subjected to an engineering analysis to determine their vulnerability and resiliency. This may be useful when proxy analysis, as dictated by the basic process, requires additional clarification.



Useful PIEVC Resources:

Protocol

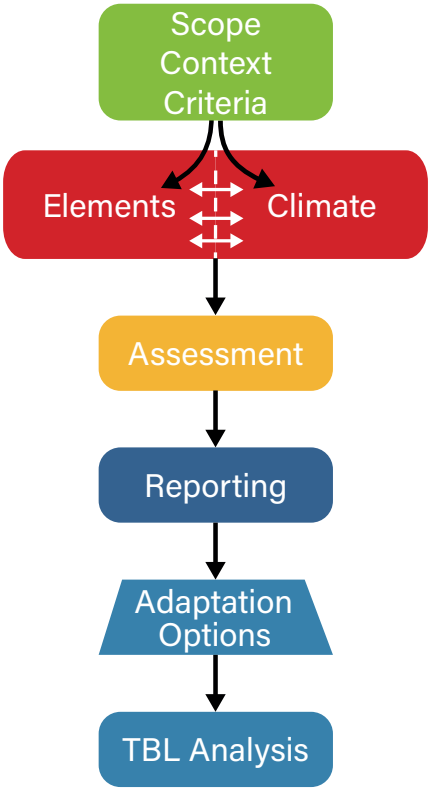
Other Useful Resources:

31000 ISO

14091 ISO

Basic Process + Triple Bottom Line

Typical Applications: When users require a richer assessment of climate adaptation options, they may choose to do triple bottom line analysis (TBL). The PIEVC Protocol has a TBL module, which guides users through a systematic process to assess the social, economic, and environmental benefits of adaptation actions. To do this analysis, a basic PIEVC process must be completed first. Recommendations from the basic process are then forwarded to other professionals to work out adaptation alternatives. These alternatives are ranked using the PIEVC TBL module.



Useful PIEVC Resources:

Protocol

Other Useful Resources:

31000 ISO

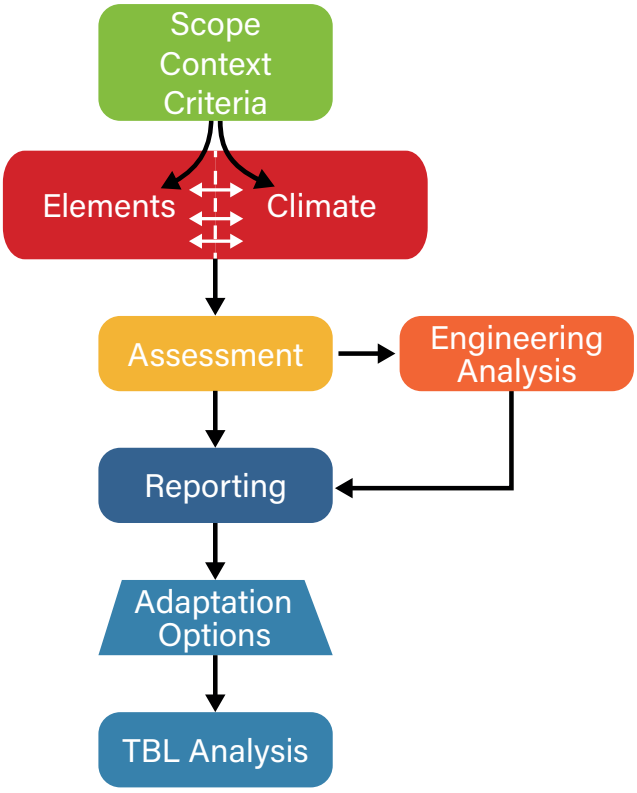
14090 ISO

14091 ISO

14092 ISO

Basic Process + Engineering Analysis + Triple Bottom Line

Typical Applications: Sometimes identified climate risks need further resolution. The PIEVC protocol offers an optional engineering analysis module. In this analysis the user assesses the vulnerability and resilience of specific infrastructure elements. The module promotes further clarity on identified risks and provides an assessment of the overall resilience of these components. This information is very useful for informing adaptation options, which can then be used in a triple bottom line analysis. This pathway represents a full application on of every module available within the PIEVC Protocol.



Useful PIEVC Resources:

Protocol

Other Useful Resources:

31000 ISO

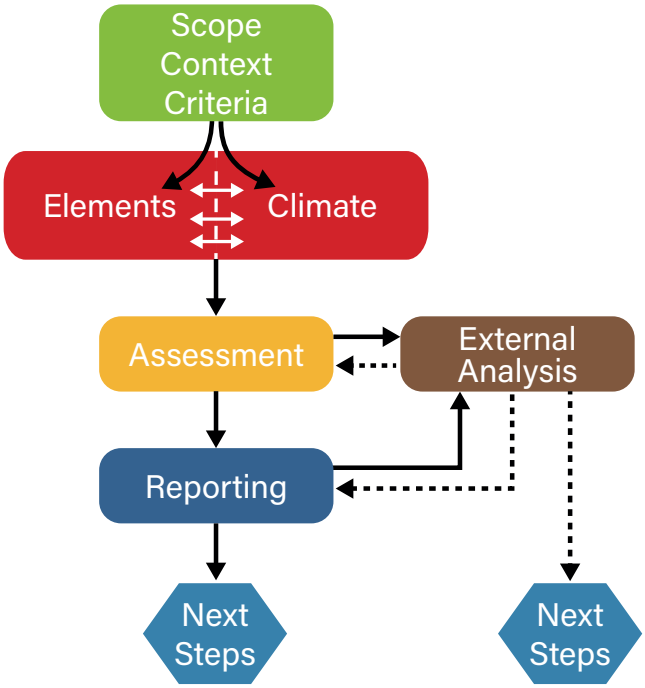
14090 ISO

14091 ISO

14092 ISO

Basic Process + External Analysis

Typical Applications: The basic PIEVC process is often used to inform external analysis, which is then used to identify adaptation actions. External analysis can include more detailed modeling, engineering, and socio-economic analysis that are not elements of the PIEVC protocol. The protocol generates meaningful information that can enhance these analyses and to support effective climate adaptation plans.



Useful PIEVC Resources:

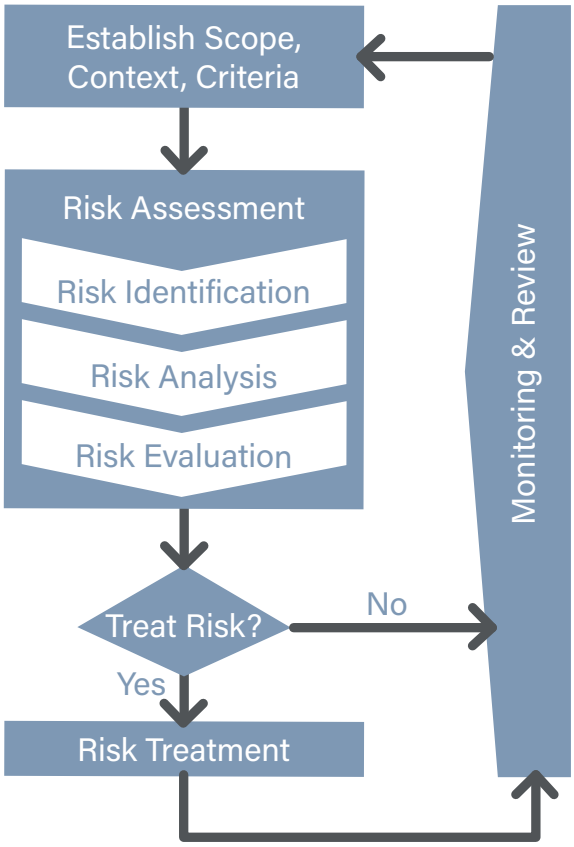
Protocol HLSG

Other Useful Resources:

31000 ISO 14090 ISO 14091 ISO 14092 ISO

An Iterative Process

PIEVC forms one part of a cycle of climate risk analysis and assessment. An entity will establish the scope, context, and criteria for an initial assessment. They may use PIEVC for that assessment. Once the assessment is complete, they will decide whether and how to treat the risks. At this stage, the cycle enters a monitoring and review phase. The entity will monitor how well the risk process addressed the issues identified in the assessment. This is used to establish the scope, context, and criteria for the next round of assessments.



Not every pass involves the same level of detail. For example, the owner may decide to do a high-level screening on the first pass. Later, with the information learned from that screening, they may do detailed assessments of defined assets. Finally, on following passes, they may once again opt for screening-level work to inform ongoing monitoring and review.

Scope, context, and criteria may vary between cycles, depending on risk drivers, priorities, and other factors. These changes can influence the PIEVC tool chosen for each pass.

ISO 31000 offers detailed guidance on the iterative nature of risk assessment.

Useful Resources:

31000 ISO

14092 ISO

Your Examples:

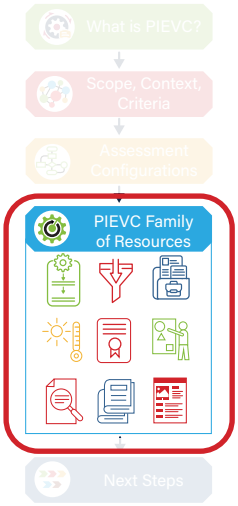
Your work may have used different pathways or examples of external analysis. These can inform and improve the ongoing development of the PIEVC family of resources. If you wish to share your experience, your input is welcome.

Your Examples

Back

Resources

The PIEVC Family of Resources includes eight categories that cover the development of climate information, high-level screening, detailed assessment, training, and certification. These resources include:



1. The PIEVC Protocol
2. The High-Level Screening Guide
3. The Portfolio Screening Manual
4. PIEVC Scoping and Data Collection Tool
5. PIEVC Certification
6. Assessment Reports
7. International Studies
8. Associated Secondary Documents

The following sections offer brief thumbnails for each of these elements and links for accessing the resources.

Back

PIEVC Protocol

The **PIEVC Engineering Protocol for Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate** (Protocol) outlines a process to assess infrastructure responses to changing climate. Information developed through the assessment process helps owners and operators incorporate adaptation into design, development, and management of existing and planned infrastructure.

The Protocol offers a step-by-step risk assessment methodology for evaluating the impact of changing climate on infrastructure. The observations, conclusions and recommendations derived from the application of the Protocol provide a structure to support decision-making.

The Protocol is divided into three sections:

1. Principles and Guidelines

- Description of the processes and organization for planning climate change risk assessments
- Applicable principles of risk management
- Principles of triple bottom line analysis
- Procedural description of the eight steps that comprise the full scope of the methodology

2. Risk Assessment Module

- Detailed procedures for executing an infrastructure climate risk assessment
- Worksheets for each step of the process

3. Triple Bottom Line Module

- Detailed for executing a triple bottom line analysis
- Worksheets covering each step of the process

Access the PIEVC Protocol

High Level Screening Guide

The **PIEVC HLSG** is designed to help infrastructure owners gain a high-level assessment of the potential risks posed by climate change to their infrastructure and related elements. Generally, the distinction between the **PIEVC HLSG** and the **PIEVC Protocol** is the level of detail pursued at each step. The **PIEVC HLSG** process is written such that information can be obtained from readily available sources and based on a high degree of professional judgment. The **PIEVC HLSG** process may also be the initial screening step before other processes or further detail assessment. It provides a simplified level of assessment for evaluating climate risk. **PIEVC HLSG** assessments:

- Use a smaller number of elements to define an infrastructure system or portfolio.
- Use climate analyses and projections from readily available sources.
- Require considerably less effort and time.
- Enables the grouping of assets by class or "like" conditions for more rapid risk screening

The High-Level Screening Guide process is an approach for undertaking vulnerability, risk and resilience assessments. It is flexible enough to be applied to full assets or systems, to a single element of infrastructure, or to an entire portfolio of numerous assets. **PIEVC HLSG** assessments result in the characterization and ranking of climate risk scenarios and the identification of those scenarios of highest potential priority for adaptation planning or more comprehensive analysis.

The **PIEVC HLSG** process requires an understanding of the elements under assessment; life of the elements in terms of timescale of the assessment; risk assessment principles; climate science, climate hazards and climate change principles; the consequence of the interaction of elements under assessment and climate; and options for developing risk actions and adaptation strategies.

Access the HLSG

Coming Soon!

Portfolio Screening Manual

The PIEVC Portfolio Screening Manual details general approaches to use the PIEVC Process (PIEVC Protocol, **PIEVC High Level Screening Guide**) on a Portfolio of assets. It is designed to:

- Offer simple, screening level analysis to support qualitative climate vulnerability and risks assessment and initial adaptation planning.
- Be an Initial step before detail adaptation planning, design, and implementation of specific resiliency measures.
- Comply with ISO 31000, 14000 series of standards
- Provide guidance on assessing a Portfolio of similar or varying assets in the same or differing geographic and climate regions.

PIEVC assessment of a portfolio follows the same principles used in a single-asset assessment. In principle, a single asset is a set of one. The definition captures this idea. One asset is the smallest form of portfolio. The approach used to assess one asset can be used for multiple assets.

A portfolio is controlled by a single entity. This addresses issues that could confound assessments of a range of similar assets owned by different entities. One key factor of portfolio assessment is the control established by one governing body applying consistent scope, context, and criteria.

Access the Portfolio Screening Manual

Coming Soon!

PIEVC Scoping and Data Collection Tool

The primary goal of the **PIEVC Scoping and Data Collection Tool (SDCT)** is to increase the efficiency of PIEVC applications by providing a better, guided, and structured way to:

1. Understand and communicate climate information requirements

2. Capture and organize climate information for risk assessment (scoring) purposes.

Steps 1 and 2 of the PIEVC Protocol – scoping, data gathering and sufficiency – are crucial and often challenging parts of the PIEVC process. These steps are often iterative, continuing into Step 3, expanding the knowledge gathered about the project boundaries, infrastructure, time horizons, climate parameters, and trends, among other key information. This part of the process is the point at which the multiple disciplines within the team must first make detailed, data-driven requests of each other.

The online tool may be used in a several project related contexts, including:

- Fully online by an engineering team, with a handover to a climate team to complete the of climate questions
- Fully online by an engineering team, with an ability to send information to potential climate service providers who would then respond to climate questions
- Collaboratively by engineering and climate teams to walk through key data collection points of Steps 1 and 2
- This could be completed either online (virtual workshop) or walked through “in-person” as part of a workshop
- As a guide for data collection for both engineering and climate teams
- To feed directly into Step 3, under future developments of the online tool
- The ultimate context of how the online tool is used within a project is likely to be decided based several factors, including team experience with PIEVC, team climate-literacy, and availability of climate expertise, among other considerations.

This tool is currently in final testing and development. It will be available soon.

Access the PIEVC Scoping and Data Collection Tool

Coming Soon!

Infrastructure Resilience Professional (IRP) Certification

The IRP Program has been designed to help infrastructure practitioners strengthen the knowledge and competencies they require to advance more climate-resilient approaches for the planning, design, and management of infrastructure. Engineers Canada – the umbrella organization for the 12 regional Canadian regulators of the engineering profession – launched the Program in 2016 as a series of courses for engineers on the PIEVC Protocol, asset management, risk management, and climate change law.

These online courses will be of interest to engineers and other professionals who are involved in the planning, procurement, design, operation, maintenance, management, and regulation of infrastructure and who need to consider the changing climate in carrying out these activities.

CRI assumed responsibility for the Program in July 2020 and began offering the courses in November 2020.

To obtain the IRP credential, engineers must successfully complete six courses: Climate Change and Infrastructure Risk Assessment – the PIEVC Protocol, Engineering Risk Management, Asset Management and Climate Resiliency, Climate Law for Infrastructure Practitioners, Climate Science for Engineers, and Climate-Smart Policy and Procurement.

Learn More About IRP Certification

Assessment Reports

The Institute for Catastrophic Loss Reduction maintains a detailed listing of previous PIEVC Assessment reports. These are available to anybody who wishes to see how successful PIEVC assessments have been conducted, and to draw on the reporting formats, experience, and expertise of other practitioners. The work can be used as a template to guide users in setting up and executing their own assessments.

It is often useful to see the limitations and experience of other practitioners, especially with similar infrastructure systems. These resources are freely available. And we encourage new users to review the database and draw on the experience of this community of experts.

Visit the PIEVC Assessment Database

International Studies

PIEVC has been used widely around the world. It has generated good results not only in Canada, but world-wide. The principles of risk, vulnerability, and climate analysis are flexible. So, PIEVC can support the needs of a wide range of studies, from small local work to large assessments of national-level portfolios.

Reports from these studies outline the benefits, roadblocks, and improvements of earlier teams. This work is being gathered in a library and will be available to teams planning new studies.

Visit the International Studies Library

Coming Soon!

Community of Practice

Risk assessment can be complex. It may call for the skills of a variety of experts. These skills may include risk management, climate data development, asset management, policy, planning, infrastructure design and operation, environmental, and others, depending on the project. Parties planning projects may wish to consult experts to assure skilled execution. But where do they find these experts?

To address this need, PIEVC is establishing a Community of Practice. These are people who are involved in climate resilience work. They will meet to discuss resilience work, training, and share their experience. This community of practice will offer a good starting point for parties planning climate studies. This will be a place of sharing, learning and skill development that can help organizations identify not only the skills they may require for their project but also experts who can offer these skills.

Visit the Community of Practice

Coming Soon!

Associated Secondary Documents

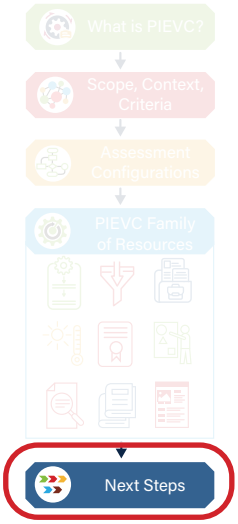
Besides assessments, the PIEVC community has also taken part in a range of supporting climate work. This ranges from green infrastructure studies, asset portfolio management, academic papers, presentations, and other documents that may benefit to those planning their own studies. This work shows what others have done. It gives a good starting point and may head off work that reproduces the efforts of others.

This work is being gathered in a library and will be available to teams planning new studies.

Visit the Associated Documents Library

Coming Soon!

Next Steps



At the end of an assessment, decision-makers will look for ways to fix the identified risks. Teams may wish to jump directly to structural changes, but this may not be the best approach. Decision-makers will often balance this with other strategies. This could include accepting the risk, looking for opportunities, further study, risk financing, or even transferring the risk.

These options form the basis for optimizing strategies though additional analysis. This could include cost benefit analysis, Triple Bottom Line Analysis, and other decision-making processes.

The team must consider how their results are going to be applied. This could be in adaptation planning, asset management planning, master and capital planning, or more detailed risk assessment and engineering.

PIEVC does not provide guidance on adaptation action. Rather, it suggests teams document possible treatment options that may be described by stakeholders and staff during their work. This can then be fed into more formal planning activities.

Further information on adaptation planning can be found in ISO 14092. ISO 31000 provide detailed guidance on risk treatment approaches.

Useful Resources:

31000 ISO

14092 ISO

Your Examples:

You may develop your own unique examples of risk treatment and adaptation. These can inform and improve the ongoing development of the PIEVC family of resources. If you wish to share your experience, your input is welcome.

Your Examples

Back

The following graphic offers a starting point for establishing a variety of adaptation options.

Detailed Vocabulary

Vocabulary	Definition
Adaptation	Process of adjustment to actual or expected climate and its effects. ▪ In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. ▪ In some natural systems, human intervention can facilitate adjustment to expected climate and its effects.
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Climate Hazard	Specific impactful event as related to the broader climate parameter category.
Climate Hazard Indicator	Specific climate values (TMax > 35C; Precip > 100mm; Freezing Rain > 30 mm, etc.) that are defined by their ability to impact an infrastructure system or component (i.e., exceed a threshold).
Climate Parameter	Broader categories of measurable climate conditions in relation to which specific climate hazards or indicators can be defined. Climate parameters include temperature, precipitation, sea-level rise, wind, etc.
Components	Physical elements or features of a composite system.
Consequence	Outcome of an event affecting objectives. ▪ An event can lead to a range of consequences. ▪ A consequence can be certain or uncertain and can have positive or negative effects on objectives ▪ Consequences can be expressed qualitatively or quantitatively.
Decision-Maker	The person or group of individuals who is responsible for making strategically important decisions based on a number of variables, including time constraints, resources available, the amount and type of information available and the number of stakeholders involved.
Element	A distinct part of a composite system. Could include physical, planning or human resources.
Engineering Vulnerability	The shortfall in the ability of public infrastructure to absorb the negative effects, and benefit from the positive effects, of changes in the climate conditions used to design and operate infrastructure.
Enterprise Risk Management	The culture, capabilities, and practices, integrated with strategy-setting and its performance, that organizations rely on to manage risk in creating, preserving, and realizing value.
Likelihood	Chance of something happening. ▪ In risk management terminology, the word "likelihood" is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically. ▪ The English term "likelihood" does not have a direct equivalent in some languages; instead, the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, "likelihood" is used with the intent that it should have the same broad interpretation as the term "probability" has in many languages other than English.
Probability	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty.
Public Risk	The possibility that human actions, or events lead to consequences that harm aspects that humans value.
Residual Risk	Risk remaining after risk treatment ▪ Residual risk can contain unidentified risk. ▪ Residual risk can also be known as "retained risk".

Vocabulary	Definition
Resilience	The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.
Risk	Effect of uncertainty ▪ An effect is a deviation from the expected. It can be positive, negative or both. ▪ An effect can arise as a result of a response, or failure to respond, to an opportunity or threat related to objectives. ▪ Uncertainty is the state, even partial, of deficiency of information retaliated to, understanding, or knowledge of, an event, its consequence, or likelihood.
Risk Appetite	Amount and type of risk that an organization is willing to pursue or retain.
Risk Owner	Person or entity with the accountability and authority to manage a risk.
Risk Profile	Description of any set of risks ▪ The set of risks can contain those that relate to the whole organization, part of the organization, or as otherwise defined.
Risk Tolerance	Organization's or stakeholder's readiness to bear the risk after risk treatment in order to achieve its objectives. ▪ Risk tolerance can be influenced by legal or regulatory requirements.
Risk Treatment	Process to modify risk 1. Risk treatment can involve: ▪ Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk; ▪ Taking or increasing risk in order to pursue an opportunity; ▪ Removing the risk source ▪ Changing the likelihood ▪ Changing the consequences ▪ Sharing the risk with another party or parties [including contracts and risk financing; and ▪ Retaining the risk by informed decision. 2. Risk treatments that deal with negative consequences are sometimes referred to as "risk mitigation", "risk elimination", "risk prevention" and "risk reduction". 3. Risk treatment can create new risks or modify existing risks.
Threshold	Point beyond which a system is deemed to be no longer effective: ▪ Economically; ▪ Socially; ▪ Technologically; or ▪ Environmentally. ▪ Also known as tipping point.
Triple Bottom Line (TBL)	A business concept that states organizations should commit to measuring their social and environmental impact—in addition to their financial performance—rather than solely focusing on generating profit, or the standard "bottom line." It can be broken down into "three Ps": profit, people, and the planet.
Vulnerability	Propensity or predisposition to be adversely affected Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

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