AS 5334—2013

Australian Standard®

Climate change adaptation for settlements and infrastructure—A risk based approach

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- Attorney General's Department (Cwlth)
- Australian Green Infrastructure Council
- Australian Institute of Architects
- Australian Institute of Landscape Architects
- Australian Local Government Association
- Australian Railway Association
- Australian Sustainability Built Environment Council
- Austroads
- Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education
- Department of Planning and Community Development, Vic.
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- Energy Networks Australia
- Engineers Australia
- Housing Industry Association
- Independent Chair
- Insurance Council of Australia
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- Planning Institute of Australia
- Property Council of Australia
- Water Services Association of Australia

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Australian Standard®

Climate change adaptation for settlements and infrastructure—A risk based approach

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PREFACE

This Standard was prepared by Standards Australia Committee BD-103, Climate Change Adaptation.

This Standard provides a general and widely applicable approach and framework for decision-makers in all organizations that play a role in the commission, design, planning, approval, construction, maintenance, management, operation and decommission of settlements and infrastructure. The Standard provides guidance on managing climate change risks and includes implementation plans for suitable and effective adaptation (treatment).

The objectives of this Standard are to—

(a) provide principles and generic guidelines on the identification and management of risks that settlements and infrastructure face from climate change; and

(b) describe a systematic approach to planning the adaptation of settlements and infrastructure based on the risk management process.

The scope of this Standard is limited to settlements and infrastructure, and is not intended for use in other areas, such as public health.

The Standard follows the International Standard, ISO 31000:2009, *Risk management—Principles and guidelines* (adopted in Australia and New Zealand as AS/NZS ISO 31000:2009), which provides a set of internationally endorsed principles and guidance on how organizations can integrate decisions about risks and responses into their existing management and decision-making processes.

It is anticipated that a range of guides will be developed to assist users in applying this Standard. These guides will provide more specific information and guidance for particular infrastructure sectors or climate attributes.

CONTENTS

Page

FOREWORD

Addressing climate change

How to deal with climate change in Australia is one of the most fundamental and far-reaching issues confronting our nation. Industry, commerce, agriculture and our way of life will be profoundly affected by rising temperatures, changing rainfall patterns, higher sea levels and the increasing frequency, severity and intensity of extreme events, such as heat waves, droughts and storms.

Sectors at risk from the effects of climate change include settlements and infrastructure (buildings, towns and cities), biological systems (threats to vulnerable species, changes to biodiversity), primary production (threats to food security, varieties and availability), health and welfare (increasing disease risks), and social stability.

As individuals and organizations grapple with the challenges of operating in a changing environment, it is clear that taking a pre-emptive approach to adapting to our changing circumstances is preferable to dealing with the increasingly severe consequences of our inaction in the future.

While this Standard has a wider relevance, it specifically deals with the impact of climate change on settlements and infrastructure, which sectors require the longest lead times to implement fundamental change.

Many of our settlements and much of our infrastructure are potentially vulnerable to the effects of climate change. Adaptation needs to commence now so that the consequences of climate change on existing and new structures can be managed. Climate change also offers some opportunities that will be advantageous and actions can be taken to ensure that these are realized.

This Standard is of relevance to all individuals and organizations who design, plan, approve, construct, maintain, operate and decommission settlements and infrastructure.

To maximize the effectiveness of adaptation measures, the Standard should be applied by those individuals and organizations in coordination and cooperation with one another and all levels of government. The impacts of climate change will both vary in their nature and level of risk from one part of the country to another. Recognizing this variation and the need for tailor-made adaptation solutions, this Standard avoids prescription and advocates a flexible approach. Adaptation planning should be based on risk management, where each case is considered in terms of the risks involved and the settlement or infrastructure item’s particular sensitivity.

The nature and extent of adaptation in each situation will depend on the costs and efforts involved compared with the benefits of adopting different adaptation strategies. Adaptation strategies include—

(a) policy and planning approaches to design or approvals;

(b) the modification, relocation or replacement of existing settlements or infrastructure; and

(c) the alteration of operations or maintenance regimes.

A major challenge for Australian individuals and organizations planning their management approach to dealing with the impacts of climate change is to build an understanding of how to adopt and develop strategies to build an appropriate level of resilience to the impacts they anticipate.

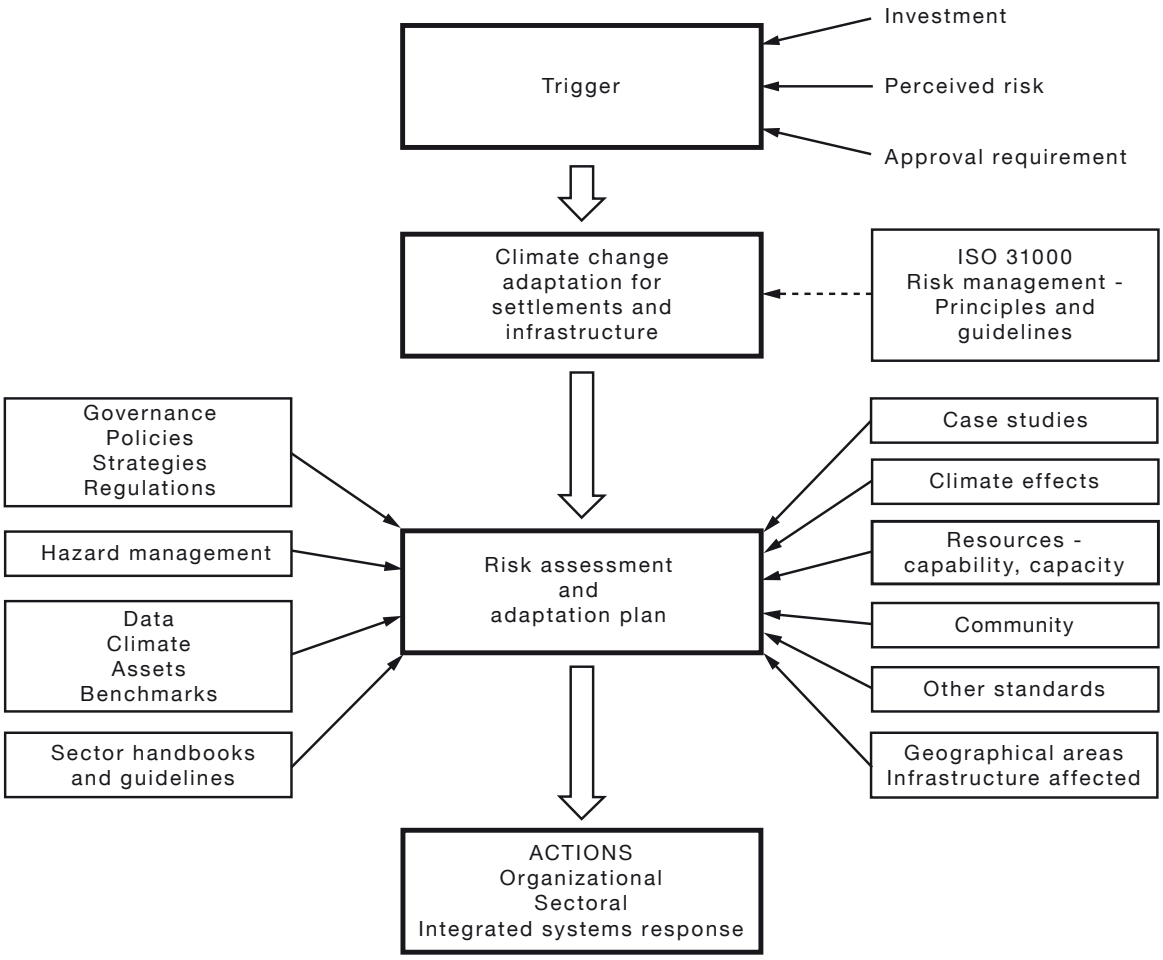
An effective way to do this is to ensure that climate change adaptation is considered as part of existing management and decision-making processes.

This Standard facilitates the integration of climate change considerations into these conventional business practices.

The Standard follows the International Standard, ISO 31000:2009, *Risk management—Principles and guidelines* (adopted in Australia and New Zealand as AS/NZS ISO 31000:2009), which provides a set of internationally endorsed principles and guidance on how organizations can integrate decisions about risks and responses into their existing management and decision-making processes.

Committee BD-103 is aware that climate change adaptation is a relatively new field and many alternative approaches to the risk management approach either exist or are in the process of being developed as suitable methodologies for adaptation of settlements and infrastructure.

The Committee has not undertaken a review of alternative methods to risk management for climate change adaptation of settlements and infrastructure. Therefore, such alternative adaptation methodologies should not be disregarded on account of this new Standard, as they may be appropriate, either on their own or in conjunction with this Standard, for a particular project or application. The following figure illustrates the approach outlined in this Standard.



APPROACH TO DEVELOPING A CLIMATE CHANGE ADAPTATION PLAN

Trigger for developing an adaptation plan

An event or occurrence that results in an organization commencing climate change risk management through adaptation is referred to as a 'trigger'. Examples of triggers are:

(a) *Investment* Where an organization is in the process of developing a significant settlement or infrastructure, as part of the project planning, it would be prudent to undertake an analysis of the risk (including any financial risk) of climate change affecting the infrastructure over its expected life. Similarly, when considering purchasing an already established settlement or infrastructure, an analysis of any potential risk to the investment should be made. This would also be advisable where a particular settlement or infrastructure is already owned by the organization. Over the life and subsequent decommissioning of settlements or infrastructure, climate change may necessitate additional expenditure or other measures.

(b) *Perceived risk* Where an organization or individual perceives that a risk could occur as a result of climate change. This perception may not relate to the more concrete need associated with financial investment, but is likely to be more intangible. An example is where local government may be concerned about projected sea level rises. Would the council be liable if it approved development in an area not yet impacted by climate change, but with potential impacts over time? Would costs for maintaining amenities and local infrastructure be impacted? The federal and state governments may also act on a perceived risk to the health and wellbeing of its citizens. Perceived risks often prompt planning policies and other instruments that provide direction to organizations and individuals.

(c) *Approval requirement* Approval for a project may be subject to a requirement to undertake a risk assessment and develop suitable treatment through an adaptation plan (and subsequent necessary actions).

It is important to be aware that early adaptation planning within a project or program tends to yield better adaptation outcomes. Options and choices are usually greater the earlier adaptation planning is carried out.

Assessment methodology

AS/NZS ISO 31000 is a well-established and universally accepted process for risk management. It is used in this Standard to guide organizations in developing effective climate change adaptation plans. It advocates that these risks should be managed in an integrated way, supported by a framework that—

(a) sets policy;

(b) demonstrates commitment;

(c) provides resources;

(d) allocates responsibility; and

(e) pursues continuous improvement.

The alignment with the well-recognized risk management Standard allows organizations that are already familiar with, or using, AS/NZS ISO 31000 to easily integrate this climate change adaptation Standard into their management processes.

Climate change risks should also be considered within the context of other risks that may affect the organization within a similar timeframe, as multiple risks may combine and result in a more severe risk. For example, organizations responsible for water supply are affected both by population growth, which increases water demand, and declining rainfall, which decreases water availability. The two factors together multiply the risk.

It is important for organizations that have gone through the risk assessment process and developed adaptation plans to ensure that these plans are implemented in a reasonable time frame. Plans must lead to quantifiable actions. Senior management should allocate responsibility within the organization, establish appropriate reporting lines, and provide adequate resources.

Information and data use and availability

Within this Standard there are a number of clearly defined steps to be taken. Many of these steps require the user to consult, integrate, or otherwise be aware of external policies, information, plans, data and guides. It is the responsibility of those undertaking the assessment to make sure they have consulted the appropriate documents.

One of the key concerns of users of this Standard is the availability of information about likely future climate. While climate models continue to improve, some uncertainty about future climate is inevitable and decisions must be made on the basis of the best available information.

Uncertainty is part of the intrinsic nature of complex systems. As the quality, quantity and communication of climate change information improves over time, the knowledge gap is expected to reduce. However, filling the knowledge gap will not remove all uncertainties when dealing with climate change information and data. It is likely that significant levels of uncertainty with regards to climate change projections will remain and adaptation planning processes will have to be flexible enough to cope with these. The lack of incontrovertible data should not be considered as a reason not to implement climate change adaptation measures.

Adaptation plans should be reviewed on a regular basis to take new data into account. Adaptation plans should be seen as ‘living documents’ that are updated and modified to take changing circumstances into account.

There are as yet no recognized central sources of climate change data, and this Standard cannot specify data sources. It will be up to individuals and organizations to locate and use the best available data. Research results published in refereed scientific journals can be a source of reliable data; however, these can often be application-specific and not necessarily suitable for general use. Care should be taken when using results from refereed journals for other applications and studies since the specificity of location, time and resolution as well as models that are calibrated differently in such reports may be very different from the application under consideration.

Information, and specific data, used in climate change adaptation studies should be current, authoritative and credible. Sources should be cited.

Summaries, critical reviews of available data, and compilations of data such as maps and charts are extremely important, particularly if they come from a credible and reliable source. These sources can be government agencies, research institutions, universities, and private institutions.

STANDARDS AUSTRALIA

Australian Standard

Climate change adaptation for settlements and infrastructure—A risk based approach

1 SCOPE

This Standard provides principles and generic guidelines on the management of the risks that settlements and infrastructure face from the consequences of climate change. In particular, it describes a systematic approach to planning the adaptation of settlements and infrastructure based on the risk management process given in AS/NZS ISO 31000:2009.

This Standard is relevant to individuals and organizations concerned with all phases in the lifecycle of settlements or infrastructure that will be affected by climate change. These phases may involve—

(a) policy and planning;

(b) creation or acquisition;

(c) utilization and maintenance; and

(d) renewal and disposal.

Both beneficial and detrimental consequences can arise from climate change.

2 APPLICATION

This Standard is not intended for the purpose of certification.

This Standard should be applied throughout the life of settlements and infrastructure.

This Standard applies to settlement planning processes as highlighted in Figure 1 and to infrastructure sectors as given in Table 1 and the climate change variables in Table 2.

This Standard is intended for use, as appropriate, by organizations to inform all decisions concerning the commissioning, design, planning, approval, construction, maintenance, operation and decommissioning of settlements and infrastructure.

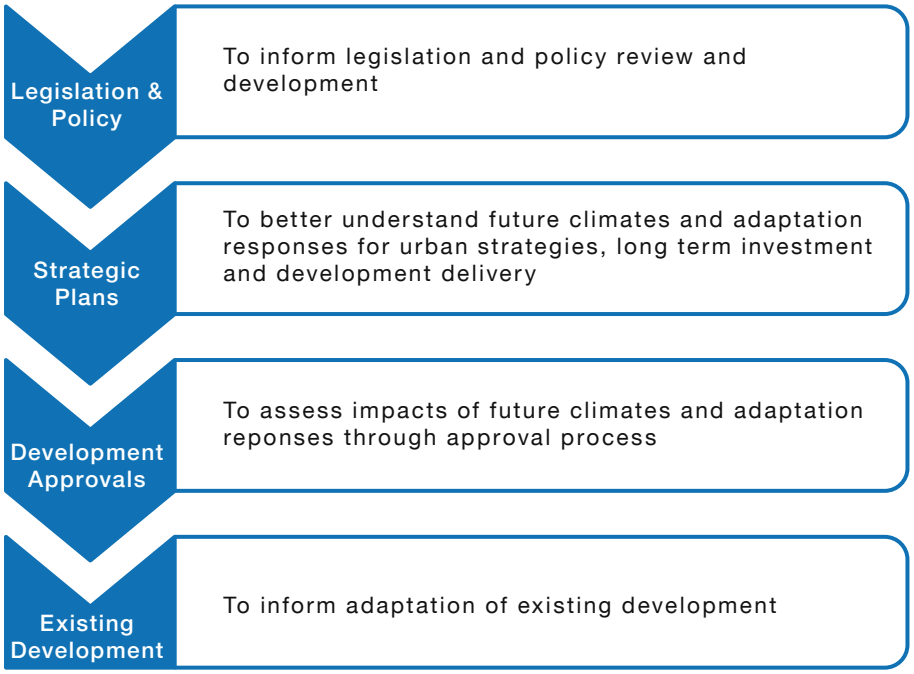


FIGURE 1 LAND USE PLANNING APPLICATION OF THIS STANDARD

TABLE 1
SETTLEMENTS AND INFRASTRUCTURE SECTORS

Sector	Component (indicative)	Notes
Places	Cities	
	Towns	
	Villages	
	Hamlets	
Buildings	Residential	All housing types including mixed use centres, multiple dwellings and public and community housing such as boarding houses
	Commercial	Includes all facilities that facilitate professional services, banking, administration centres, call centres, resorts, etc.
	Industrial	Includes processing, manufacturing and warehousing
	Recreational	Includes major event facilities
	Retail	Includes shopping malls, bulky goods centres and mixed use centres
	Public	Includes schools, hospitals, universities and courts
	Historic	Heritage listed and state significant
	Tourism	Public and private facilities
Energy	Electricity generation	
	Electricity transmission and distribution	
	Oil and gas storage, transmission and distribution	
	Liquid fuels storage and distribution	
Water	Water storage	Includes dams and header tanks
	Water supply and distribution	Includes pipes and pumps
	Sewerage	Includes pipes, pumps and sewerage treatment plants
	Irrigation	Includes pipes and pumps
	Drainage	Includes pipes and pumps, open drains such as swales, concrete formed structures, bio-filtration systems and other water sensitive urban design elements
Green infrastructure (see Clause 4.20)	Public open space and private domain landscapes	Includes regional, district and local parks, streetscapes, trees and gardens, private open space
	Natural landscape systems	Includes conserved systems such as river corridors, urban National Parks and State Forests, vegetation and habitat reserves, foreshores and cliffs
	Cultural landscapes	Includes urban public lands such as botanic gardens, archaeological (indigenous and settlement) sites and monuments
	Urban agriculture	Includes community gardens, urban farms for food production and/or commercial plant production

(*continued*)

TABLE 1 (*continued*)

Sector	Component (indicative)	Notes
Transport	Roads	Includes all gazetted roads, sealed or unsealed, formed and unformed
	Tunnels	All transport tunnels
	Bridges	All transport bridges
	Rail	Includes railway stations, fixed structures and rolling stock
	Airports	
	Ports	Incudes jetties, wharves, sea walls, navigational aids
	Pedestrian and cycle	Includes footpaths and cycle ways
Communication	Fixed line	Includes all overhead lines
	Underground	
	Transmission facilities	Includes data, radio, TV and phone systems
ICT	Critical systems and data	
Resource development	Mining, oil and gas extraction	
	Forestry	
	Fisheries	Includes aquaculture

TABLE 2

CLIMATE CHANGE VARIABLES

Element	Climate change variables (indicative)	Notes
Sea	Sea level rise	Coastal processes including erosion and accretion
	Storm surge and storm tide	
	Surface temperature	
	Currents and waves	Includes strength and direction, wave height and period
	Atmospheric salt	Salt spray
Rainfall	Average annual rainfall	Long term changes
	Extreme rainfall events	Includes frequency and intensity, leads to changes in the intensity and frequency of flooding and to landslides and erosion, and to intensity of electrical storms
	Drought	Changes to frequency, intensity and duration
Temperature	Average annual temperature	Long term changes
	Extreme temperature events	Include changes to maximum and minimum events, and duration (e.g. increased intensity and duration of heatwaves)
Wind	Gales and extreme wind events	Winds in excess of 8 on the Beaufort scale
	Storms	Includes snow, hail, dust
	Cyclones	Includes the terms typhoon and hurricane
	Prevailing wind direction	
Relative humidity	Average annual	Long term changes

(*continued*)

TABLE 2 (*continued*)

Element	Climate change variables (indicative)	Notes
Soil	Moisture	
	Saltwater intrusion	
	Salinity	
	Runoff	
	Ground stability	
	Groundwater level	
pH	Soil	
	Fresh water	
	Marine and estuarine	
Bush fire risk	Fire danger index	
Fog	Intensity, frequency and duration	
Solar radiation		Total amount of energy from the sun, measured in watts per square metre. It includes both direct and diffuse (reflected) radiation
	Temperature	
	Cloud cover	
Snow	Snow cover and snow line	
Hail	Hail size and location	
Lightning	Frequency and location of strikes	
Evapotranspiration	Evaporation rates	

3 REFERENCED DOCUMENT

The following document is referred to in this Standard:

AS/NZS ISO
31000 Risk management—Principles and guidelines

Bibliographic citations are listed after the Appendices.

4 DEFINITIONS

For the purposes of this Standard, the following terms and definitions apply.

4.1 Adaptation

Changes made in response to the likely threats and opportunities arising from climate variability and climate change.

NOTE: Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in climatic conditions.

4.2 Adaptive capacity

Ability of a system to respond to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

NOTES:

1 Adaptive capacity can be an inherent property or it could have been developed as a result of established policy, planning or design decisions.

2 Adaptive capacity reflects existing controls including contingency plans and their effectiveness.

[Adapted from IPCC, Third Assessment Report 2001]

4.3 Asset(s)

Something that has potential or actual value to an organization.

NOTES:

1 Value can be tangible or intangible, financial or non-financial; examples of assets include financial assets, human resource assets, physical assets, and organization reputation.

2 Value includes consideration of risks and liabilities, and can be positive or negative at different stages of the asset's life.

3 For most organizations, physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, intellectual property rights, reputation or agreements.

4.4 Climate

Average weather based on the statistical description in terms of the mean and variability of relevant quantities, such as temperature, precipitation and wind, over an extended period of time.

NOTES:

1 The classical period for averaging these variables as defined by the World Meteorological Organization is 30 years.

2 Synthesis here implies more than simple averaging. Various methods are used to represent climate, e.g. both average and extreme values, frequencies of values within stated ranges, frequencies of weather types with associated values of elements.

3 The main climatic elements are precipitation, temperature, humidity, sunshine, wind velocity, and such phenomena as fog, frost, thunder, gale; cloudiness, grass minimum temperature, and soil temperature at various depths may also be included.

4 Climatic data are usually expressed in terms of an individual calendar month or season and are determined over a period (usually about 30 years) long enough to ensure that representative values for the month or season are obtained.

4.5 Climate change

A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).

4.6 Climate scenario

Coherent, plausible description of a possible future state of the climate.

NOTE: A climate scenario should not be viewed as a projection of the future climate. Rather, it provides a means of understanding the potential impacts of climate change, and identifying the potential threats and opportunities to an organization created by an uncertain future climate.

4.7 Climate change scenario

Difference between a climate scenario and the current climate.

4.8 Co-benefit

An additional benefit from an action that is undertaken to achieve a particular purpose that is not directly related to that purpose.

4.9 Communication and consultation

Continual and iterative processes that an organization conducts to provide, share or obtain information and to engage in dialogue with stakeholders and others regarding the management of risk.

NOTES:

1 The information can relate to the existence, nature, form, likelihood, severity, evaluation, acceptability, treatment or other aspects of the management of risk.

2 Consultation is a two-way process of informed communication between an organization and its stakeholders or others on an issue prior to making a decision or determining a direction on a particular issue. Consultation is—

(a) a process which impacts on a decision through influence rather than power; and

(b) an input to decision making, not joint decision making.

[ISO Guide 73:2009, Definition 3.2.1]

4.10 Consequence

Outcome of an event affecting objectives.

NOTES:

1 An event can lead to a range of consequences.

2 A consequence can be certain or uncertain and can have positive or negative effects on objectives.

3 Consequences can be expressed qualitatively or quantitatively.

4 Initial consequences can escalate through knock-on effects.

[ISO Guide 73:2009, Definition 3.6.1.3]

4.11 Contingency plan

Any plan of action that allows an organization to respond to events should they occur.

NOTES:

1 This includes all plans that deal with stabilization, continuity of critical business functions and recovery.

2 Some types of contingency plans may have been described by terms such as ‘business continuity plan’ and ‘disaster recovery plan’.

[AS/NZS 5050:2010, Definition 1.3.8]

4.12 Contingent capability

Supplementary resources provided specifically to enable an organization to respond to events should they occur.

NOTE: May be required to make a contingency plan viable.

[AS/NZS 5050:2010, Definition 1.3.9]

4.13 Control

Measure that is modifying risk.

NOTES:

1 Controls include any process, policy, device, practice, or other actions which modify risk.

2 Controls may not always exert the intended or assumed modifying effect.

[ISO Guide 73:2009, Definition 3.8.1.1]

4.14 Event

Occurrence or change of a particular set of circumstances.

NOTES:

1 An event can be one or more occurrences, and can have several causes.

2 An event can consist of something not happening.

3 An event can sometimes be referred to as an ‘incident’ or ‘accident’.

4 An event without consequences can also be referred to as a ‘near miss’, ‘incident’, ‘near hit’ or ‘close call’.

[ISO Guide 73:2009, Definition 3.5.1.3]

4.15 Establishing the context

Defining the external and internal parameters to be taken into account when managing risk, and setting the scope and risk criteria for the risk management policy.

[ISO Guide 73:2009, Definition 3.3.1]

4.16 External context

External environment in which the organization seeks to achieve its objectives.

NOTE: External context can include—

(a) the cultural, social, political, legal, regulatory, financial, technological, economic, natural and competitive environment, whether international, national, regional or local;

(b) key drivers and trends having impact on the objectives of the organization; and

(c) relationships with, and perceptions and values of, external stakeholders.

[ISO Guide 73:2009, Definition 3.3.1.1]

4.17 Extreme weather event

Weather phenomena that are at the extremes of the historical distribution, including especially severe or unseasonal weather.

4.18 Impact

A threat or an opportunity that may arise as a result of either the weather or climate change both in the short and long term, and represents the fact that the issue is one that is constantly evolving.

4.19 Infrastructure

Assets and systems of assets that support our society.

NOTE: This includes buildings, open space systems, public domain areas and associated landscape infrastructure, and transport, water, power and communications assets.

4.20 Green infrastructure

The network of natural and built landscape assets, including green spaces and water systems within and between settlements.

NOTE: Individual components of this environmental network, such as gardens, parks, recreation areas, highway verges and waterways, are sometimes referred to as ‘green infrastructure assets’.

4.21 Internal context

Internal environment in which the organization seeks to achieve its objectives.

NOTE: Internal context can include—

(a) governance, organizational structure, roles and accountabilities;

(b) policies, objectives, and the strategies that are in place to achieve them;

(c) the capabilities, understood in terms of resources and knowledge (e.g. capital, time, people, processes, systems and technologies);

(d) perceptions and values of internal stakeholders;

(e) information systems, information flows and decision-making processes (both formal and informal);

(f) relationships with and perceptions and values of internal stakeholders;

(g) the organization's culture;

(h) standards, guidelines and models adopted by the organization; and

(i) form and extent of contractual relationships.

[ISO Guide 73:2009, Definition 3.3.1.2]

4.22 Level of risk

Magnitude of a risk or combination of risks, expressed in terms of the combination of consequences and their likelihood.

[ISO Guide 73:2009, Definition 3.6.1.8]

4.23 Life cycle

Time interval that commences with the identification of the need for an asset and terminates with the decommissioning of the asset or any associated liabilities.

NOTE: The principal stages of an asset's life cycle can include—define policy and plan, create/acquire, utilize, maintain and renew/dispose.

4.24 Likelihood

Chance of something happening.

NOTES:

1 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 (such as a probability or a frequency over a given time period).

2 The term 'likelihood' does not have a direct equivalent in some languages; instead, the equivalent of the term 'probability' is often used. However, '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.

[ISO Guide 73:2009, Definition 3.6.1.1]

4.25 Mitigation

Reducing causes of climate change.

NOTE: In most cases this would mean reducing the levels of carbon dioxide but may also apply to other factors such as methane.

4.26 Monitoring

Continual checking, supervising, critically observing or determining the status in order to identify change from the performance level required or expected.

NOTE: Monitoring can be applied to a risk management framework, risk management process, risk or control.

[ISO Guide 73:2009, Definition 3.8.2.1]

4.27 Organization

Group of people and facilities with an arrangement of responsibilities, authorities and relationships.

Example:

Company, corporation, firm, enterprise, institution, charity, sole trader, association, or parts or combination thereof.

NOTES:

1 The arrangement is generally orderly.

2 An organization can be public or private.

[ISO 9000:2005, Definition 3.3.1]

4.28 Residual risk

Risk remaining after risk treatment.

NOTES:

1 Residual risk can contain unidentified risk.

2 Residual risk can also be known as ‘retained risk’.

[ISO Guide 73:2009, Definition 3.8.1.6]

4.29 Resilience

Adaptive capacity of an organization in a complex and changing environment.

[ISO Guide 73:2009, Definition 3.8.1.7]

4.30 Review

Activity undertaken to determine the suitability, adequacy and effectiveness of the subject matter to achieve established objectives.

NOTE: Review can be applied to a risk management framework, risk management process, risk or control.

[ISO Guide 73:2009, Definition 3.8.2.2]

4.31 Risk

Effect of uncertainty on objectives.

NOTES:

1 An effect is a deviation from the expected—positive or negative.

2 Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).

3 Risk is often characterized by reference to potential events and consequences, or a combination of these.

4 Risk can be expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

5 Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood.

[ISO Guide 73:2009, Definition 1.1]

4.32 Risk analysis

Process to comprehend the nature of risk and to determine the level of risk.

NOTES:

1 Risk analysis provides the basis for risk evaluation and decisions about risk treatment.

2 Risk analysis includes risk estimation.

[ISO Guide 73:2009, Definition 3.6.1]

4.33 Risk assessment

Overall process of risk identification, risk analysis and risk evaluation.

[ISO Guide 73:2009, Definition 3.4.1]

4.34 Risk attitude

Organization's approach to assess and eventually pursue, retain, take or turn away from risk.

[ISO Guide 73:2009, Definition 3.7.1.1]

4.35 Risk criteria

Terms of reference against which the significance of risk is evaluated.

NOTES:

1 Risk criteria are based on organizational objectives, and external and internal context.

2 Risk criteria can be derived from standards, laws, policies and other requirements.

[ISO Guide 73:2009, Definition 3.3.1.3]

4.36 Risk evaluation

Process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable.

NOTE: Risk evaluation assists in the decision about risk treatment.

[ISO Guide 73:2009, Definition 3.7.1]

4.37 Risk identification

Process of finding, recognizing and describing risks.

NOTES:

1 Risk identification involves the identification of risk sources, events, their causes and their potential consequences.

2 Risk identification can involve historical data, theoretical analysis, informed and expert opinions, and stakeholder's needs.

[ISO Guide 73:2009, Definition 3.5.1]

4.38 Risk management

Coordinated activities to direct and control an organization with regard to risk.

[ISO Guide 73:2009, Definition 2.1]

4.39 Risk management framework

Set of components that provides the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization.

NOTES:

1 The foundations include the policy, objectives, mandate and commitment to manage risk.

2 The organizational arrangements include plans, relationships, accountabilities, resources, processes and activities.

3 The risk management framework is embedded within the organization's overall strategic and operational policies and practices.

[ISO Guide 73:2009, Definition 2.1.1]

4.40 Risk management plan

Scheme within the risk management framework specifying the approach, the management components and resources to be applied to the management of risk.

NOTES:

1 Management components typically include procedures, practices, assignment of responsibilities, sequence and timing of activities.

2 The risk management plan can be applied to a particular product, process and project, and part or whole of the organization.

[ISO Guide 73:2009, Definition 2.1.3]

4.41 Risk management policy

Statement of the overall intentions and direction of an organization related to risk management.

[ISO Guide 73:2009, Definition 2.1.2]

4.42 Risk management process

Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk.

[ISO Guide 73:2009, Definition 3.1]

4.43 Risk owner

Person or entity with the accountability and authority to manage the risk.

[ISO Guide 73:2009, Definition 3.5.1.5]

4.44 Risk profile

Description of any set of risks.

NOTE: The set of risks can contain those that relate to the whole organization, part of the organization, or as otherwise defined.

[ISO Guide 73:2009, Definition 3.8.2.5]

4.45 Risk source

Element which alone or in combination has the intrinsic potential to give rise to risk.

NOTE: A risk source can be tangible or intangible.

[ISO Guide 73:2009, Definition 3.5.1.2]

4.46 Risk treatment

Process to modify risk.

NOTES:

1 Risk treatment can involve—

(a) avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk;

(b) taking or increasing risk in order to pursue an opportunity;

(c) removing the risk source;

(d) changing the likelihood;

(e) changing the consequences;

(f) sharing the risk with another party or parties (including insurance and risk financing); and

(g) retaining the risk by informed choice.

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.

[ISO Guide 73:2009, Definition 3.8.1]

4.47 Secondary risk

A risk that will arise as a result of responding to another risk.

4.48 Sensitivity (to climate change)

Degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.

NOTE: The effect may be direct or indirect.

[IPCC, Third Assessment Report]

4.49 Settlement

Existing or proposed permanent or temporary community in which people live without being specific as to size, population or importance.

4.50 Stakeholder

Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity.

NOTE: A decision maker can be a stakeholder.

[ISO Guide 73:2009, Definition 3.2.1.1]

4.51 Vulnerability (to climate change)

Degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change including climate variability and extremes.

NOTE: Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

[IPCC, 4th Assessment Report 2007]

5 PRINCIPLES

The following principles should be taken into account in order for an organization to effectively manage the risk of climate change through adaptation:

(a) *The effects of climate change are not contained within jurisdictional boundaries; adaptation may require policy, planning and action at national, state, regional and local levels*.

Adaptation requires a coordinated approach involving all those organizations that are concerned with settlements and infrastructure. Infrastructure items may cross jurisdictional boundaries or, if they are impacted by climate change, may lead to consequences being felt in other jurisdictions. Policy, planning and operational decisions may also have cross-jurisdictional consequences.

(b) *Climate change risk management needs to be an integral part of decision making concerning settlements and infrastructure*.

Risk management provides an effective and transparent basis for adapting to climate change. The outputs from the risk management process provide a recognized and justifiable basis for making decisions about the level of risk that can be tolerated and the additional risk treatment (adaptation) required.

An infrastructure should ensure that climate change risks and treatments are considered under the same framework as used for other operational or organizational risks and treatments. This will help to ensure that resources are allocated to climate change adaptation in a manner that is internally consistent and appropriate.

(c) *The risk from climate change and the requirement for adaptation needs to be considered for all stages in the lifecycle of settlements and infrastructure*.

When planning new settlements and infrastructure, organizations should adopt a life cycle model and should integrate elements of adaptation into all stages in that cycle so that the treatment of risk from climate change is optimized and appropriate.

It is particularly important that there is an emphasis on the identification of adaptation options at the earliest stages of settlement and infrastructure proposals. Typically, the range of adaptation options for a given project narrows and/or becomes more costly (economically and socially) as it progresses through planning, design, construction and operation phases. On this basis, strategic land use planning can provide highly efficient opportunities for implementing long term adaptation measures.

(d) *Climate change risk management and adaptation requires the involvement of stakeholders in settlements and infrastructure*.

Successful adaptation planning and implementation for settlements and infrastructure requires input from (and alignment of) key stakeholders. This requires organizations to adopt a broad view of stakeholders, and to involve as many as possible in the risk assessment and adaptation planning process.

(e) *When managing the risk from climate change, organizations need to use the best available authoritative and relevant information*.

The consequences of climate change on settlements and infrastructure will vary significantly according to location, the timing of the events or changes and the pattern of usage and demand. While broad-based information may be suitable for an initial assessment of risk, wherever possible, regional or location-specific data should be used.

(f) *When information about climate change is updated the specification and performance requirements for settlements and infrastructure need to be reconsidered*.

Decisions based on historical climate data may no longer be robust, as science indicates that the climate has changed significantly over the last 50 years and will continue to do so. Information about climate change, its impacts and appropriate adaptation actions is constantly improving. In particular, that information is becoming more detailed and specific.

6 FRAMEWORK

6.1 General

The framework defined in this Clause 6 identifies the foundations, structures and capabilities that will enable organizations to consistently integrate climate change adaptation planning and implementation into their existing management and decision-making processes (see Clause 7).

The components of the framework and their interrelationships are set out in Figure 2.

To enable effective management of the risks from climate change to settlements and infrastructure, the organization’s risk management framework should include additional attributes specific to climate change risks, as set out in this Clause 6.

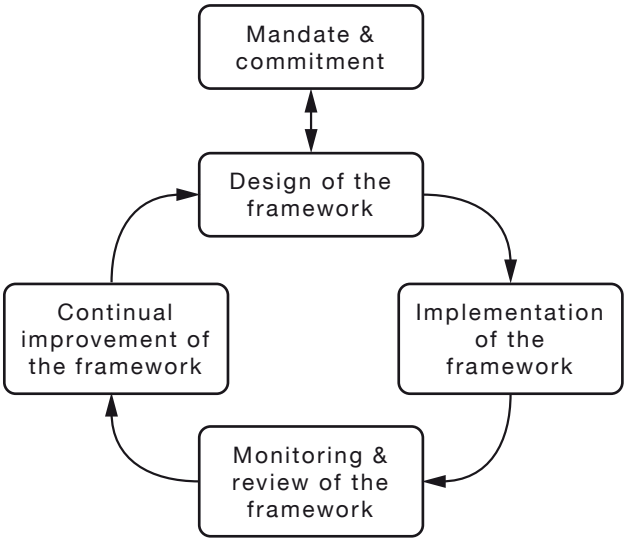


FIGURE 2 COMPONENTS OF A CLIMATE CHANGE RISK MANAGEMENT FRAMEWORK
(adapted from AS/NZS ISO 31000)

6.2 Mandate and commitment

Ensuring effective climate change adaptation requires strong and sustained commitment by management at all levels of the organization.

To demonstrate mandate and commitment, management should—

(a) define and endorse the organization's policy for managing the risks from climate change to settlements and infrastructure;

(b) ensure that the organization's culture and risk management policies are aligned;

(c) determine adaptation performance indicators that align with performance indicators of the organization;

(d) ensure legal and regulatory compliance;

(e) assign accountabilities and responsibilities at appropriate levels within the organization for adaptation;

(f) ensure that the necessary resources are allocated to managing the risks from climate change to settlements and infrastructure;

(g) generate awareness by communicating the benefits of adaptation to relevant stakeholders; and

(h) ensure that the framework for managing the risks from climate change to settlements and infrastructure continues to remain relevant to the particular organization.

6.3 Design of the framework

6.3.1 *The organization and its context*

The framework should take into account the external and internal context of the organization, taking particular account of uncertainty.

The external factors include, but are not limited to the following:

(a) Defining broad climate change scenarios that define how climate is projected (or assumed) to change in the future.

(b) The social and cultural, legal, regulatory, financial, technological, economic, natural and competitive environment, whether international, national, regional or local.

(c) Key drivers and trends having impact on the objectives of the organization.

(d) The form and nature of relationships including interdependencies with, and perceptions and therefore values of, external stakeholders.

The internal factors include, but are not limited to the following:

(i) Governance arrangements including policies, structures, roles and accountabilities and decision-making processes (both formal and informal).

(ii) Objectives and the strategies that are in place to achieve them.

(iii) Capabilities, understood in terms of resources and knowledge (e.g. capital, time, people, processes, systems and technologies).

(iv) Information systems, reporting and other information flows.

(v) The organization's culture.

(vi) Standards and guidelines adopted by the organization.

For each of the above factors, past experience, the present situation and future circumstances, trends and projections should be considered.

Establishing the context is discussed in more detail in Clause 7.3.1 in relation to specific risk management exercises.

6.3.2 *Establishing the policy*

The policy should clearly state the organization's objectives for, and commitment to, the management of risks from climate change to settlements and infrastructure and typically should address the following:

(a) The organization's rationale for managing the risks from climate change to settlements and infrastructure.

(b) Links between the organization's corporate objectives, policies, climate-related policy and corporate risk management framework.

(c) Accountabilities and responsibilities for managing the risks from climate change to settlements and infrastructure and for adaptation.

(d) Commitment to make the necessary resources available to assist those accountable and responsible for managing the risks from climate change to settlements and infrastructure.

(e) The way in which performance against this policy will be measured and reported.

(f) Commitment to review and improve the policy and framework periodically and in response to new information on climate change, the likely impacts and to adaptation.

The policy, which preferably will form part of the organization's overall policy about managing risk, should be communicated appropriately.

6.3.3 *Accountability*

The organization should ensure that there is accountability, authority and appropriate competence for all aspects of the management of risks from climate change to settlements and infrastructure. This can be facilitated by—

(a) identifying risk owners that have the accountability and authority to manage this type of risk;

(b) identifying who is accountable for the development, implementation and maintenance of the framework for managing this type of risk;

(c) identifying other responsibilities of people at all levels in the organization who contribute to adaptation;

(d) establishing performance measurement and external and internal reporting and escalation processes; and

(e) ensuring appropriate recognition of accountability and performance.

6.3.4 *Integration*

Management of the risks from climate change to settlements and infrastructure should be embedded in all the organization's practices and processes in a way that it is relevant, effective and efficient. Therefore, the process for managing this type of risk should be part of, and not separate from, those organizational processes. In particular, climate change risk should be integrated into the processes for policy development and planning, plans of management commissioning, approval, permitting, design, construction, alteration, maintenance, management, operation or decommissioning.

Specifically, the organization should develop a risk management plan that describes how the management of each type of risk will be integrated in all of the organization's practices and processes.

6.3.5 *Resources*

The organization should allocate appropriate resources to each step in the process for managing the risk from climate change. This should consider—

(a) funding and financial provisions;

(b) people, skills, experience and competence;

(c) tools, facilities, plant and equipment, methods and supporting infrastructure; and

(d) information and knowledge management systems.

6.3.6 *Communication and reporting*

The organization's framework for managing the risks from climate change to settlements and infrastructure should include communication and reporting arrangements. This will assist in—

(a) building awareness, confidence and understanding;

(b) meeting legal and regulatory requirements; and

(c) exchanging information with stakeholders.

6.4 Implementation of the framework

In implementing or enhancing a framework for managing the risks from climate change to settlements and infrastructure, the organization should—

(a) define the appropriate timing and strategy for implementation;

(b) integrate the framework across existing organizational arrangements;

(c) comply with legal and regulatory requirements;

(d) hold information and training sessions; and

(e) ensure that the process for managing risk (see Clause 8) is applied throughout the organization for this type of risk.

6.5 Monitoring and review of the framework

To ensure the framework remains effective and appropriate, the organization should—

(a) measure the performance of the framework against indicators, which are periodically reviewed for appropriateness;

(b) periodically measure progress against, and deviation from, the risk management plan;

(c) periodically review whether the framework, policy and plan are still appropriate, given the organization's external and internal context including monitoring new developments in the science of climate change, its impacts and adaptation;

(d) report on how well the risk management policy is being followed; and

(e) evaluate the effectiveness of its process for the management of the risks from climate change settlements and infrastructure.

6.6 Continual improvement of the framework

Based on results of monitoring and reviews, decisions should be made on how the framework can be improved.

7 PROCESS

7.1 General

The process for managing risks from climate change to settlements and infrastructure should be—

(a) an integral part of the organization's management activities;

(b) embedded in the culture and practices;

(c) recognize uncertainties in climate change; and

(d) tailored to the business processes of the organization.

It comprises the activities described in Clauses 7.2, 7.3 and 8 of this Standard. The risk management process is summarized in Figure 3.

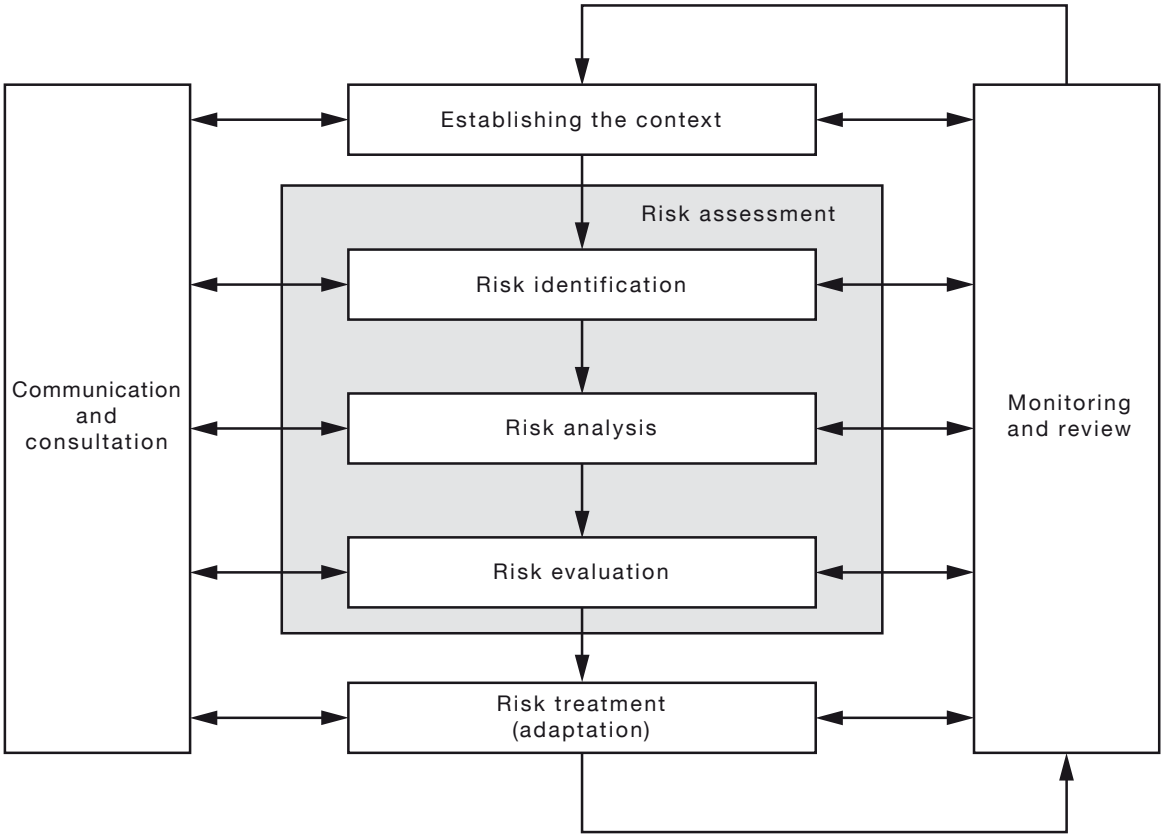


FIGURE 3 RISK MANAGEMENT PROCESS
(adapted from AS/NZS ISO 31000)

7.2 Continuous elements of the risk management process

7.2.1 *Communication and consultation*

High quality communication and consultation are required because the risks from climate change are uncertain, complex and may involve extreme weather events and slow onset consequences that are outside normal human experience. Plans for communication and consultation should be developed at an early stage.

Organizations involved with the approval, licensing and permitting of settlements and infrastructure have a particular role to communicate to other organizations and to the public as to why a pre-emptive and long-term view to adaptation is required.

Communication and consultation with external and internal stakeholders should facilitate truthful, relevant, accurate and understandable exchanges of information. This should take place during all stages of the process for managing the risks from climate change to settlements and infrastructure. Ongoing communication and consultation helps ensure that those accountable for implementing the risk management process and the stakeholders each understand the basis on which decisions are made about adaptation and have the opportunity to contribute appropriately to the decision-making process.

Communication and consultation should take into account legitimate needs for confidentiality and commercial sensitivity.

Consultation with stakeholders and others can provide access to relevant information and experience that will assist in managing the risk from climate change. Consultation should be undertaken in a way that ensures that those being consulted understand the context in which their responses are likely to be applied. They should be given sufficient contextual information and time in order to provide considered input.

The views of stakeholders may include judgements about the level of risk based on their perceptions that may reflect personal or organizational values, needs, knowledge, assumptions, concepts and concerns.

7.2.2 *Monitoring and review*

As part of its monitoring and review activities, an organization should gain assurance that the process for the management of the risks from climate change to settlements and infrastructure is working effectively and within the policy (see Clause 6.3.2).

Monitoring and review should be a planned part of the process for managing risk. It should involve regular checking or surveillance in order to provide assurance of the ongoing adequacy and effectiveness of adaptation measures and the risk management process itself.

To be effective, assurance should comprise a combination of the following activities:

(a) Continuous (or at least frequent) monitoring through routinely measuring or checking particular parameters or indicators.

(b) Line management reviews of the risks from climate change to settlements and infrastructure, progress with adaptation plans and adaptive capacity.

(c) Independent review and audit, using both internal and external audit staff.

The organization’s monitoring and review processes should be aimed at—

(i) detecting any change in the climate change scenarios previously used;

(ii) detecting changes in the sensitivity of a particular settlement or item of infrastructure;

(iii) tracking progress on implementation of adaptation plans;

(iv) ensuring that controls (adaptive capacity), including contingency plans and resources, their maintenance and testing, are effective and efficient in both design and operation;

(v) obtaining further information to improve the risk assessment;

(vi) analysing and learning lessons from extreme weather events (including near-misses), testing and maintenance activities, and changes, trends, successes and failures;

(vii) identifying new risks from climate change to settlements and infrastructure; and

(viii) checking consistency of similar risk ratings and climate change adaptation actions between different managers or projects within the business.

Responsibilities for monitoring and review should be defined clearly. Elements of monitoring and review may be incorporated in the performance measures of individuals in the organization with responsibilities for management of the risks from climate change to settlements and infrastructure.

The results of monitoring and review should be recorded and externally and internally reported as appropriate—preferably as part of the organization's routine performance management and reporting arrangements. The results should also be used as an input to the review of the framework for managing this type of risk (see Clause 7.3).

7.3 Elements of the climate risk management process

7.3.1 *Establishing the context*

7.3.1.1 *General*

In establishing the context, the organization should—

(a) articulate its objectives, including those concerned with the risks from climate change to the settlements and infrastructure concerned;

(b) define the climate change context using climate change scenarios;

(c) identify the relevant stakeholders and their objectives;

(d) define the external and internal factors that give rise to the risks from climate change to settlements and infrastructure;

(e) set risk criteria; and

(f) define the scope, purpose and structure of the particular risk management activity.

Many of these parameters are similar to those considered in the design of the framework (see Clause 7). However, when establishing the context for the risk management process, they need to be considered in greater detail, including how they relate to managing the risks from climate change to particular settlements and infrastructure items.

7.3.1.2 *Objectives*

The objectives of the organization including its explicit and implicit goals, values and imperatives with respect to climate change and the adaptation of settlements and infrastructure should be identified. The objectives of some organizations may be set by statute.

7.3.1.3 *Establishing the climate change context*

To manage the risks from climate change to settlements and infrastructure, it is necessary to define how climate is likely to change in the future. This is achieved using climate change scenarios that provide a plausible summary of the changes to climate variables that could apply to a particular geographical region and within a particular timescale.

Small changes in climate may make a profound difference to the level of risk or the adaptation actions stemming from it. The uncertainty in applying climate change scenarios to a particular settlement or infrastructure item should be clearly understood and stated.

The following six steps should be applied to determine the climate change context that will inform the climate risk assessment and subsequent adaptation responses:

(a) *Define the greenhouse gas emissions scenario* The greenhouse gas emissions are usually selected from a selection of scenarios provided by the Intergovernmental Panel on Climate Change (IPCC). Using both a moderate and high greenhouse gas emissions scenario is preferable to provide a range of future scenarios to guide the risk assessment. The low greenhouse gas emissions scenarios presented by the IPCC are very unlikely to be achieved and should be used cautiously.

(b) *Define future time slices* The selection of a few sample time slices to inform the change in risk over time is required. For longer lived settlements or infrastructure (e.g. bridges), a range of time slices (such as 2040, 2070 and 2100) should be considered. Projects or assets with a shorter life expectancy (e.g. a 30 year mineral extraction operation) may only need to use a 2030 or 2040 time slice. For detailed analysis of a site or region (e.g. a cost-benefit analysis) may require annual, monthly or daily time slices over several decades.

(c) *Define the climate variables* The selection of climate variables to be assessed should be determined by the climate sensitivity of a range of asset types, activities and locations. The indirect consequences of climate change on critical supply chain assets and services such as access, power and water should usually be considered even if the direct impact occurs outside the boundary of the site being assessed. The types of climate variables used for climate sensitivity should be considerate of regional characteristics.

An example of the type of initial screening that can be used for assessing the climate change sensitivity of a range of assets is provided in Appendix A.

(d) *Selection of climate data* The climate change data should be current, authoritative and credible to allow assessment of the full range of future climatic conditions in the region being assessed. Filtered sets of climate change data should be publicly available for most locations. The range of climate change related variables should be derived from the selected data.

NOTE: Information on specific consequences from changes to climate variables, e.g. extreme rainfall, may not be available and may change the assessment process chosen.

Some climate change projections have low spatial resolution. Actual climate conditions can vary significantly over distances of tens of kilometres, particularly in areas with strong vertical relief. Techniques are available for generating projections with finer spatial resolutions which can take into account local landscape characteristics. Experts should be consulted on whether higher resolution climate projections will be useful for your risk assessment.

Published climate change projections will be updated and become more precise as new climate change information becomes available. Relevant and authoritative data should be used. The data used, and the process and reasons for determining its relevance to the risk assessment to be undertaken, should be recorded.

(e) *Determine other associated impact studies required* For detailed analysis of sites and assets, the use of impact studies such as flood modelling are usually required to assess the consequences of extreme events or accelerated degradation of assets over time. These impact studies need to use climate change data as selected in the steps above to inform their results. The results from inundation and erosion impact studies for storm surge events influenced by sea level rise and combined with impacts of increased extreme rainfall events is necessary for detailed climate change risk assessments along the coast.

(f) *Obtain past meteorological record* The past meteorological data for a region or site should be sourced to determine the long term average for each climate variable (past 100 years if available), scale of past extreme events, recent trends of change in past 30 years recognizing that in many locations, the changing climate has been observed already. It is acknowledged that for some locations the past meteorological record is sometimes unavailable or inconsistently recorded, any proxy data used for a location should be identified and justified.

7.3.1.4 *Establish the external context*

The external context characterizes pertinent features of the external environment in which the organization seeks to achieve its objectives, including its climate change and adaptation objectives. The external context may include, but is not limited to, the following:

(a) The social and cultural, political, legal, regulatory, financial, technological, economic, natural and competitive environment, whether international, national, regional or local.

(b) External infrastructure on which the organization depends including markets, utilities, transport, green infrastructure, suppliers, and logistics.

(c) Uses, dependencies and known sensitivity of the settlement or infrastructure to natural and weather events.

(d) Long term plans and trends for the settlement or infrastructure, including projected changes in use and demographic changes.

(e) Key external drivers and trends having impact on the objectives of the organization.

(f) The form and nature of relationships including interdependencies with, and perceptions and therefore values of, internal and external stakeholders.

To assess the risks to settlements and infrastructure at future points in time climate change projections are used. However, as those settlements and infrastructure will also change in time, possibly as a result of climate change, organizations should also consider future projections for variables such as—

(i) land use;

(ii) demographics;

(iii) health and disease for humans and for plants and animals;

(iv) industry and commerce;

(v) supporting infrastructure, logistics and communications systems, etc.; and

(vi) natural ecosystems and urban and rural landscapes.

Much infrastructure has been optimized for current climatic conditions and the historical return periods for extreme weather events. Climate change may result in the infrastructure exceeding its design limits. Organizations should therefore establish the design bases of critical infrastructure items including assumptions about climatic conditions and compare these to climate change scenarios.

Stakeholder analysis should be conducted to allow the organization to identify those individuals, groups or organizations who need to be involved to achieve successful adaptation. These will usually include important external groups such as local communities, suppliers, associates, clients or customers, competitors, legal or regulatory authorities, funders, shareholders and insurers.

Stakeholder analysis involves analysing the main stakeholder groups and their objectives. It can also include the identification of communication needs in each case as this will assist with communication and consultation (see Clause 7.2.1).

7.3.1.5 *Establish the internal context*

The internal context characterizes pertinent features of the internal environment in which the organization seeks to achieve its objectives. This can include, but is not limited to the following:

(a) Governance arrangements, including policies, structures, plans of management roles and accountabilities, decision-making processes (both formal and informal) and corporate risk management framework.

(b) Standards and guidelines adopted by the organization.

(c) The strategies that are in place to achieve objectives concerning the management of the risks from climate change to settlements and infrastructure.

(d) Capabilities, understood in terms of resources and knowledge (e.g. time, people, processes and systems).

(e) Internal stakeholders and their objectives, such as the executive management, staff and workforce.

(f) Physical assets, tools, facilities, plant and equipment, technologies and internal infrastructure.

(g) Capital, financial arrangements and income streams.

(h) Information systems, reporting and other information flows.

(i) The organization's culture.

(j) Current insurance and risk sharing arrangements.

7.3.1.6 *Establishing the context of the risk management process*

It is important to establish the scope of the risk management activity by defining what the risk assessment is to encompass and what it is to exclude. The scope should be defined in terms of the following:

(a) The settlement or infrastructure to be considered, its purpose and functions with future trends and dependencies.

(b) The geographical region or area to be considered.

(c) The boundaries of the risk assessment in terms of the role and responsibility of the organization.

(d) The time horizon to be covered.

An organization with geographically or operationally diverse activities and responsibilities may choose to conduct a risk assessment for each activity. Some care is required when doing this to ensure that activities that only make sense across the entire organization are not overlooked.

When establishing the scope of the risk assessment, the organization should—

(i) address the entire settlement or infrastructure;

(ii) if necessary, split the scope into parts, look carefully for potential gaps between the parts and consider whether a separate assessment is required to deal with issues that are not confined to one part; and

(iii) make sure the geographical area, organizational boundaries, operational or functional boundaries and timeframe are specified explicitly for each assessment.

To ensure that the process of risk identification is systematic and efficient, it is advisable to divide the settlement or organization into discrete elements, areas or aspects. These 'key elements' provide a framework for thinking about risks efficiently and making good use of the time and resources devoted to the subsequent activities of risk identification, analysis and evaluation.

A set of key elements may include items of different types. However, the set of key elements should be comprehensive and achieve an appropriate level of detail.

7.3.1.7 *Defining risk criteria*

The organization should define criteria to be used to evaluate the significance of the risks from climate change to settlements and infrastructure. These criteria should be consistent with the risk criteria that the organization uses for other forms of risk, its values and objectives. Some criteria can be imposed by, or derived from, legal and regulatory requirements. Risk criteria should be consistent with the organization's climate change risk management policy (see Clause 7.3.2), be defined at the beginning of any risk management process and be reviewed regularly.

Risk criteria can be defined in terms of measures of consequences, their likelihood and how these can be combined to express a level of risk and a priority for attention.

When developing consequence measures, the organization should consider the following:

(a) The nature and magnitude of the consequences that can occur as a result of climate change and how they will be measured.

(b) The secondary consequences for the settlement or infrastructure from climate change in terms of human safety and health, loss of utility, financial impact and disruption.

(c) Aversion to certain types of consequences.

(d) The timing and time frame of the consequences.

(e) The persistence and reversibility of the consequences.

Appendix B provides an example of the type of risk consequence criteria that may be used in an organization. For large organizations there could be a range of criteria covering different assets. Different sets of criteria could be based on, for example, capital cost, criticality of the asset, life expectancy of the asset and social disruption.

When developing likelihood measures, the organization should consider—

(i) how likelihood will be defined; and

(ii) the timeframe(s) of the likelihood.

Appendix C provides an example of the type of likelihood criteria that may be used in an organization.

Consequences and likelihoods are combined to develop a risk rating matrix. This matrix acts as criteria for the organization to use when evaluating risks as part of their risk assessment process. When combining consequences and likelihoods, the organization should consider—

(A) how the level of risk is to be determined;

(B) the organization's risk attitude, given uncertainties about future climate change, its impacts and the performance of adaptation measures;

(C) any criteria or limits imposed by legislation;

(D) the views of stakeholders; and

(E) the level at which risk would become acceptable or tolerable.

Appendix D provides an example of a risk rating matrix. Organizations may choose to develop a series of criteria for use in different circumstances and it is unlikely that there is a 'one size fits all' set of criteria.

7.3.2 *Risk assessment*

7.3.2.1 *General*

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. It is conducted by organizations when one of the triggers mentioned in the Foreword requires the assessment of a particular asset(s) or project.

Before assessment can be completed the framework (Clause 6), the context (Clause 7.3.1.3) and the criteria (Clause 7.3.1.7) should have been established.

NOTE: It is possible to develop the criteria at the same time as the assessment is being carried out; however, it is preferable to finalize the criteria first since this will become an objective measure against which the assessment can be compared.

7.3.2.2 *Risk identification*

The aims of this step are to generate a comprehensive list of risks based on climate changes that might significantly affect the settlement or infrastructure, and to understand whether these risks may lead to beneficial or detrimental outcomes.

The identification of the risks from climate change should consider average and extreme weather events, the manner in which the settlement or infrastructure could be impacted and the causes of the events and the types of consequence.

Each risk should be expressed in terms of—

(a) what could happen;

(b) what it would lead to in terms of the effect on the organization's objectives;

(c) the causes; and

(d) the existing controls and adaptive capacity.

Comprehensive identification is critical, because a risk that is not identified at this stage will not be included in further analysis. Identification should include all risks, whether or not the organization can exercise any direct control.

While future climate scenarios include an increasing number of potentially important climate variables, they may not be presented in a form, or at a level of detail, most relevant to certain settlements or infrastructure items. It is important not to constrain risk identification because a potentially relevant variable is not included in a particular scenario or report.

Risk identification should include examination of the domino effect of particular consequences, including flow-on, cascading and cumulative effects. For example, the failure of a single infrastructure item or nearby group of items could then affect nearby settlements or even destabilize a regional or national network.

Risk identification should also consider a wide range of consequences for each climate change scenario or event. As well as identifying what might happen, it is necessary to consider possible causes and ways that consequences can occur. All significant causes and consequences should be considered.

Risk identification should consider risks that involve a combination of events or situations occurring at the same time since these can produce severe consequences for settlements and infrastructure, create great challenges for communities, and threaten the security of supplies from infrastructure items. For example, if climate events affect a number of settlements or an entire region or regions, the nation's ability to respond might be severely compromised and lead to more severe secondary consequences. Multiple simultaneous events can put great strain on contingency plans and contingent resources.

The organization should apply risk identification tools and techniques that are suited to its capabilities and to the types of risks from climate change being faced. Relevant and up-to-date information is important and people with appropriate knowledge should be involved in identifying risks.

7.3.2.3 *Risk analysis*

Risk analysis in relation to climate change involves developing an understanding of the risk (refer to Clause 7.3.1.3). Risk analysis provides an input to risk evaluation and to decisions on whether risks need to be treated, and on the most appropriate adaptation strategies. Risk analysis can also provide an input into making decisions where choices must be made and the adaptation options involve different types and levels of risk.

Risk analysis involves considering how climate change variables might affect settlements and infrastructure positively or negatively. The range of possible consequences to infrastructure objectives should be considered and, where practicable, information on the likelihood of particular effects obtained. Factors which might affect the consequences or how likely they are to occur should be identified. Existing adaptive capacity and its effectiveness and efficiency should be taken into account.

When analysing the risks from climate change to settlements and infrastructure it is important to consider the interdependence of different risks and their sources. Where the risks from climate change are likely to affect a large area or region the risk analysis should take into account how the region could respond and the capability of contingency plans and resources to respond to impacts at a wide scale.

Risk analysis can be undertaken with varying degrees of detail, depending on the risk, the purpose of the analysis, and the information, data and resources available. When there are multiple risks to be considered it may be useful to screen them using a qualitative consideration of either consequences or level of risk. This will allow the organization to identify the following:

(a) Whether the overall risk level, when compared with criteria, will be acceptable or tolerable.

(b) Any existing forms of adaptation that adequately treat the risks.

(c) Those risks for which the only reasonable form of adaptation is the development of contingency plans and contingent capability.

(d) Those risks where more detailed risk analysis is required so that the risk can be better understood and so that appropriate adaptation can be planned and implemented.

The confidence in determination of the level of risk and its sensitivity to preconditions and assumptions should be considered in the analysis, and communicated effectively to decision makers and, as appropriate, other stakeholders. Factors, such as divergence of opinion among experts, uncertainty, availability, quality, quantity and ongoing relevance of information or limitations on modelling, should be stated, and may be emphasized. Sensitivity testing should be used to demonstrate the sensitivity of the level of risk to sources of uncertainty.

7.3.2.4 *Detailed risk analysis*

Detailed risk analysis will be required where—

(a) the risk is not clearly acceptable or tolerable;

(b) the consequences are complex or uncertain;

(c) there is a range of possible secondary consequences;

(d) it is necessary to take into account how the settlements and infrastructure will change in time as a result of climate change;

(e) there are correlations between different risks;

(f) it becomes necessary to test out a range of options for adaptation where the options will modify the risk in different ways; and

(g) where the options for adaptation will introduce additional risks.

Often this detailed risk analysis will require quantification and modelling to accommodate uncertainty in climate change scenarios and in the expected response of particular settlements and infrastructure.

One or more risk analysis tools, such as process mapping and event and fault tree analyses may be required for this type of analysis. More complex quantitative analysis and modelling may also be required to understand some aspects of vulnerability and dependencies between areas or elements of the settlement or infrastructure and dependent or connected systems.

Vulnerability analysis involves the detailed examination of how climate change variability and weather events and the impacts of climate change may affect a particular settlement or infrastructure or specific areas, elements or functions of those. This more detailed form of analysis, examines how a settlement or infrastructure will respond to a particular climate change event given its sensitivity to climate changes. The adaptive capacity of the settlement or infrastructure can reduce the vulnerability depending on the strength of institutional, infrastructural, social, financial, economic and environmental capacities to respond to impacts and withstand changes. The key steps in vulnerability analysis are depicted in Figure 4.

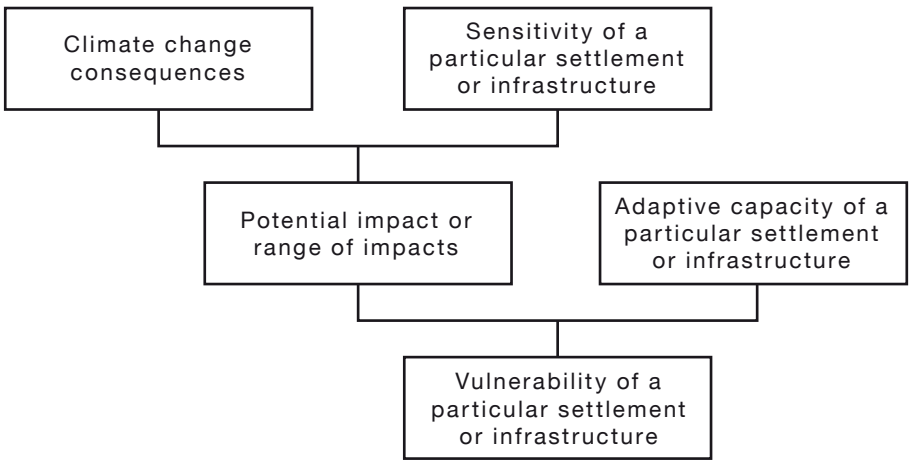


FIGURE 4 VULNERABILITY ANALYSIS—KEY STEPS

7.3.2.5 *Risk evaluation*

Risk evaluation is used to help the organization decide which risks need treatment and the priority for treatment implementation.

Risk evaluation is based on the outcomes of risk analysis (consequences and likelihood), and involves comparing the level of risk found during the analysis step with risk criteria established. The organization should also identify the order in which risks are to be treated.

Decisions on the risks to be further treated, and their priority, can be assisted by considering the potential consequences identified during the analysis and should also take account of the wider context of the risks arising from climate change, including legal requirements and the impact on other parties involved in the settlement or affected by the infrastructure.

In some circumstances, risk evaluation may lead to a decision to undertake additional risk analysis. The risk evaluation can also lead to a decision not to treat the risks in any way other than maintaining existing controls and forms of adaptation.

The risk evaluation step is closely associated with the subsequent step of risk treatment (adaptation), as options for adaptation should be compared in terms of their effectiveness in modifying the risks compared with risk criteria defined and the cost and difficulty of implementation. When estimating the consequences of adaptation, in addition to the local benefits, organizations should take into account the wider regional, state, national and social, economic and environmental impacts associated with treating the risks from climate change to settlements and infrastructure.

8 ADAPTATION (RISK TREATMENT)

8.1 General

Adaptation involves developing and then selecting one or more options for modifying the risks from climate change on settlements and infrastructure, and implementing those options.

Adaptation involves the following cyclical process:

(a) Selecting one or more adaptation options.

(b) Deciding whether, either alone or in combination with other adaptation actions or controls, residual risk levels would become tolerable.

(c) If not tolerable, planning a new adaptation action or set of actions.

(d) Assessing the effectiveness of the new adaptation actions when compared with the risk criteria previously set (see Clause 7.3.1.7).

This process is depicted in Figure 5.

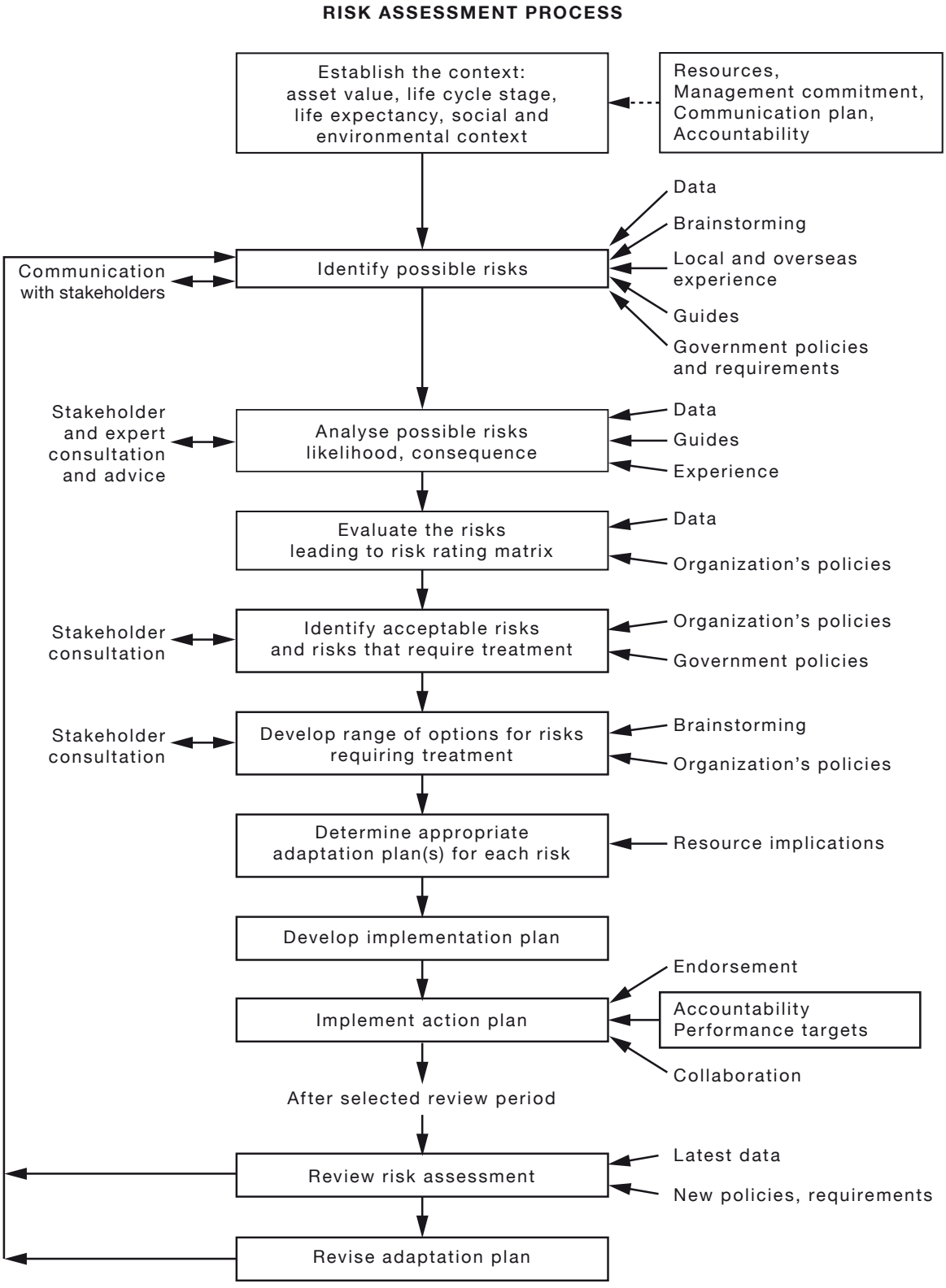


FIGURE 5 PROCESS FOR DEVELOPING AND SELECTING ADAPTATION OPTIONS

8.2 Developing options for adaptation

Once the risks to be treated have been decided (Clause 7.3.2.5) the next step is to list any controls or actions already in place that would address that risk and develop a range of additional possible options for treating each risk if necessary. The most appropriate actions can then be selected (Clause 8.3).

Options for adaptation are not necessarily mutually exclusive or appropriate. They may build on or overlap with existing controls or actions to address other business risks. Also, options may arise that would be justified under all plausible future climate scenarios and as such do not need to be delayed or complicated by debates on the accuracy of climate change science and projections. Options may include the following (see also Table 3 for an example of an adaptation option assessment form):

(a) Avoiding the risk.

(b) Taking or increasing the risk.

(c) Removing the risk source.

(d) Changing the likelihood.

(e) Changing the consequences.

(f) Transferring or sharing the risk with another party or parties.

(g) Retaining the risk.

In general, organizations should adopt a life cycle model when developing options for the adaptation of settlements and infrastructure. The life cycle should contain phases that cover—

(i) creation or acquisition;

(ii) utilization and maintenance; and

(iii) renewal and disposal,

of the settlement or infrastructure item concerned.

Each of the options given above should be considered in relation to each of the phases.

The life cycle model should be applied for the current and remaining phases of existing settlements and infrastructure.

8.3 Selection of adaptation options

Once the possible options for adaptation have been determined for each risk, the most appropriate option(s) needs to be selected. This involves comparing performance against suitable criteria, e.g. balancing the costs and difficulty of implementation against the benefits derived, with regard to legal, regulatory and other requirements such as social responsibility and the protection of the natural environment.

Adaptation options should still be considered even if the event is extremely unlikely but there is a possibility of catastrophic consequences. In such instances, adaptation responses should be rigorously tested to ensure that resulting policy decisions are robust. Assessing the net benefits of available options remains an important part of decision making.

Factors that could be considered in the selection of adaptation options include the following:

(a) Effectiveness and robustness of the adaptation—over the life of the settlement or infrastructure including flexibility of the option in terms of its ability to respond to changing conditions of use and climate and the impacts from climate change.

(b) Practicability of implementation and ease of maintenance including technical capability, availability of human resources. Compatibility with existing systems within the settlement or infrastructure.

(c) Economic efficiency of operation and ongoing maintenance including funding options and their availability for adaptation and whether the adaptation can, itself, generate revenue.

(d) Co-benefits over and above those that come from the direct treatment of the risks from climate change; or net benefits under a range of plausible future climates.

(e) Equity implications of the adaptation options for all potentially affected stakeholders.

(f) Greenhouse gas emission implications of adaptation options.

A suitable template for comparing options is given in Table 3. The organization should determine the acceptability levels for the different criteria under economic efficiency and consequences of action/inaction.

The costs and benefits of adaptation should involve the consideration of all forms of disadvantages and benefits even if they cannot be quantified in financial terms. In addition to the local benefits, organizations should take into account the wider regional, state, national, social, economic and environmental disadvantages and benefits.

When treating risks from climate change to settlements and infrastructure, the value of the future benefits from adaptation should be clearly discounted to allow valid comparisons with the costs incurred now or at some time in the future, noting however, that there are limitations to discounting techniques when dealing with long time periods and low probability events that can have extremely high consequences.

A number of adaptation measures can be considered and applied either individually or in combination. The settlement or infrastructure will normally benefit from the adoption of a combination of adaptation measures.

When selecting adaptation options, the organization should consider the values and perceptions of stakeholders and the most appropriate ways to communicate with them. Where adaptation could impact on stakeholders, these stakeholders should be involved in the decision. Though equally effective, some forms of adaptation may be more acceptable to some stakeholders than to others.

The final outcome of this process will be the identification of one (or more) adaptation options that can be used to treat each identified risk.

TABLE 3

ADAPTATION OPTION ASSESSMENT

Risk	Option	Economic efficiency									Consequences of action/inaction						
		Effectiveness	Cost	Funding options	Time to implement	Duration	Technical feasibility	Human capability	Regulatory impact	Community acceptance	Benefit	Climate change impact	Social impact	Environ-mental impact	Co-benefits	Secondary risks	Residual risk
A	a																
	b																
	c																
	d																
	e																
B	a																
	b																
	c																
	d																
C	a																
	b																
	c																
	d																

8.4 Preparing and implementing adaptation plans

Once the necessary option(s) for treating the climate change risk have been identified, it is necessary to develop an adaptation plan for treating those risks that require ongoing management. This plan should then be used by the organization to implement their response to the threats posed by climate change.

The adaptation plan should clearly identify the priority order in which individual adaptation actions should be implemented and their timing. The information provided in these plans should include—

(a) the reasons for selecting particular adaptation options, including expected benefits to be gained;

(b) a description of the critical assumptions and key sources of variability and uncertainty, and their importance to the adaptation plan;

(c) those who are accountable for approving the plan and those responsible for implementing the plan;

(d) proposed actions;

(e) resource requirements including contingencies;

(f) performance measures and constraints;

(g) reporting and monitoring requirements; and

(h) timing and schedule.

Adaptation plans should be integrated with the management, planning and implementation processes of the organization and discussed and agreed with appropriate stakeholders.

Adaptation can also introduce secondary risks that need to be assessed, treated, monitored and reviewed. These secondary risks should be incorporated into the same adaptation plan as the original risk and not treated as a new risk. The link between the two risks should be identified and maintained.

Decision makers and other stakeholders should be aware of the nature and extent of the residual risk to the settlement or infrastructure from climate change after risk adaptation plans have been implemented. There should be clear agreement on who is the risk owner.

8.5 Monitoring and review

Regular monitoring, evaluation, review and, where appropriate, amendment of adaptation actions are part of the continual improvement/adaptive management that needs to be applied to the implementation of adaptation actions. Review periods should be set out in the adaptation plans.

Adaptation can itself introduce secondary risks. A significant risk can be the failure or ineffectiveness of the adaptation measure itself. Monitoring should be an integral part of the adaptation plan to give assurance that the measures remain effective.

Climate change science and projections are progressing at a rapid rate. Therefore, in some cases, adaptation applied during the planning and design stage of a settlement or infrastructure should allow for further, progressive adaptation. This is particularly important given the context of significant uncertainties that will remain regarding climate change projections, climate change impacts and their consequences, and the novel and/or innovative nature of some adaptation measures. For this reason adaptation plans should be regularly reviewed.

The review period should be based on factors such as business budgeting and planning cycles, release of new climate change projections, reporting requirements and other relevant factors. Different parts of the climate change risk management system and adaptation plans may need to be reviewed at different timeframes to ensure the business is compliant with the risk management system, reporting as required, and planning to withstand the most recent scientific projections.

9 RECORDING THE RISK MANAGEMENT PROCESS

Risk management activities should be traceable. In the risk management process, records provide the foundation for improvement in methods and tools, as well as in the overall process.

With the considerable life spans of settlements and infrastructure and the time scales of climate change, the organization should record and retain information on the risk assessment and the basis and justification for adaptation so that it is available for future reference.

The following decisions concerning the creation of records should be taken into account:

(a) The organization’s needs for continuous learning.

(b) Benefits of re-using information for management purposes.

(c) Costs and efforts involved in creating and maintaining records.

(d) Legal, regulatory and operational needs for records.

(e) Method of access, ease of retrieval and storage arrangements.

(f) Retention period.

(g) Sensitivity of information.

APPENDIX A

EXAMPLE OF CLIMATE CHANGE EXPOSURE AND INFRASTRUCTURE SENSITIVITY MATRIX

The selection of climate variables to be assessed should be determined by the climate sensitivity of a range of asset types, activities and locations. The indirect impacts of climate change should usually be considered even if the direct impact occurs outside the boundary of the site being assessed.

Tables A1, A2 and A3 provide examples of the types of initial screening that can be used for assessing the climate change sensitivity of a range of assets.

TABLE A1

CLIMATE CHANGE EXPOSURE AND INFRASTRUCTURE SENSITIVITY MATRIX—SEA AND RAINFALL

Sector	Component	Variable						
		Sea				Rainfall		
		Sea level rise	Storm surge and storm tide	Surface temperature	Currents and waves	Annual average rainfall	Extreme rainfall events (flooding)	Drought
Energy	Electricity generation	■	■			■	■	■
	Electricity transmission and distribution	■	■				■	■
	Oil and gas extraction and production	■	■	■	■		■	
	Gas transmission and distribution	■	■	■			■	■
	Liquid fuels storage and distribution	■	■				■	■
Water	Water storage	■	■			■	■	■
	Water supply	■	■			■	■	■
	Sewerage	■	■			■	■	■
	Irrigation	■	■			■	■	■
	Drainage	■	■			■	■	■
Transport	Roads	■	■			■	■	■
	Tunnels	■	■			■	■	
	Bridges	■	■				■	
	Rail	■	■				■	
	Airports	■	■				■	
	Ports	■	■	■	■		■	
	Pedestrian and cycle	■	■			■	■	■
Communication	Fixed line	■	■				■	
	Underground	■	■			■	■	■
	Transmission facilities	■	■				■	

(*continued*)

TABLE A1 (*continued*)

Sector	Component	Variable						
		Sea				Rainfall		
		Sea level rise	Storm surge and storm tide	Surface temperature	Currents and waves	Annual average rainfall	Extreme rainfall events (flooding)	Drought
Buildings and settlements	Residential	■	■				■	■
	Commercial	■	■				■	■
	Industrial	■	■				■	■
	Recreational	■	■				■	■
	Public	■	■				■	■
	Retail	■	■				■	■
	Institutional	■	■				■	■
	Historic	■	■				■	■
	Tourism	■	■	■	■		■	■
Resource development	Mining	■	■			■	■	■
	Forestry	■	■			■	■	■
	Fisheries	■	■	■	■			
	Agriculture	■	■			■	■	■
Cultural	Sacred sites	■	■				■	
	Archaeological sites	■	■				■	
	Indigenous sites and settlement sites	■	■				■	
	Monuments	■	■				■	
Green	Trees and gardens	■	■	■	■	■	■	■
	Natural landscape systems	■	■	■	■			■
	Open spaces	■	■					
	Public parks and squares	■	■					■
	Urban agriculture	■	■			■		■

LEGEND:

□ = Negligible Risk—Presents 'negligible' risk within the probability of natural variation.

■ = Definite Risk—Presents 'definite' risk within the probability of natural variation.

TABLE A2

CLIMATE CHANGE EXPOSURE AND INFRASTRUCTURE SENSITIVITY MATRIX—TEMPERATURE, WIND AND RELATIVE HUMIDITY

Sector	Component	Variable							
		Temperature			Wind			Relative humidity	
		Annual average temperature	Extreme temperature events	Solar radiation	Gales and extreme wind events	Storms (snow, hail, dust, lightning)	Cyclones	Annual average humidity	Evaporation rates
Energy	Electricity generation								
	Electricity transmission and distribution								
	Oil and gas extraction and production								
	Gas transmission and distribution								
	Liquid fuels storage and distribution								
Water	Water storage								
	Water supply								
	Sewerage								
	Irrigation								
	Drainage								
Transport	Roads								
	Tunnels								
	Bridges								
	Rail								
	Airports								
	Ports								
	Pedestrian and cycle								
Communication	Fixed line								
	Underground								
	Transmission facilities								

(*continued*)

TABLE A2 (*continued*)

Sector	Component	Variable							
		Temperature			Wind			Relative humidity	
		Annual average temperature	Extreme temperature events	Solar radiation	Gales and extreme wind events	Storms (snow, hail, dust, lightning)	Cyclones	Annual average humidity	Evaporation rates
Buildings and settlements	Residential								
	Commercial								
	Industrial								
	Recreational								
	Public								
	Retail								
	Institutional								
	Historic								
	Tourism								
Resource development	Mining								
	Forestry								
	Fisheries								
	Agriculture								
Cultural	Sacred sites								
	Archaeological sites								
	Indigenous sites and settlement sites								
	Monuments								
Green	Trees and gardens								
	Natural landscape systems								
	Open spaces								
	Public parks and squares								
	Urban agriculture								

LEGEND:

= Negligible Risk—Presents 'negligible' risk within the probability of natural variation.

= Definite Risk—Presents 'definite' risk within the probability of natural variation.

TABLE A3

CLIMATE CHANGE EXPOSURE AND INFRASTRUCTURE SENSITIVITY MATRIX—SOIL, pH AND BUSH FIRE RISK

Sector	Component	Variable							
		Soil				pH			Bush fire risk
		Moisture	Salinity	Runoff	Stability	Soil	Fresh water	Marine and estuarine	Fire danger index
Energy	Electricity generation				■				■
	Electricity transmission and distribution	■			■	■			■
	Oil and gas extraction and production				■			■	■
	Gas transmission and distribution	■			■	■			■
	Liquid fuels storage and distribution	■			■	■			■
Water	Water storage		■	■	■				■
	Water supply								■
	Sewerage	■	■		■	■	■		
	Irrigation		■		■	■	■		
	Drainage	■	■		■	■	■		
Transport	Roads	■	■		■	■			■
	Tunnels		■		■	■			
	Bridges				■		■		■
	Rail				■				■
	Airports		■						■
	Ports							■	
	Pedestrian and cycle	■	■		■	■			■
Communication	Fixed line	■			■				■
	Underground	■	■		■	■			
	Transmission facilities				■				■

(*continued*)

TABLE A3 (*continued*)

Sector	Component	Variable							
		Soil				pH			Bush fire risk
		Moisture	Salinity	Runoff	Stability	Soil	Fresh water	Marine and estuarine	Fire danger index
Buildings and settlements	Residential	■	■		■				■
	Commercial	■	■		■				■
	Industrial	■	■		■				■
	Recreational	■	■		■		■	■	■
	Public	■	■		■				■
	Retail	■	■		■				■
	Institutional	■	■		■				■
	Historic	■	■		■				■
	Tourism	■	■		■		■	■	■
Resource development	Mining	■	■	■	■				■
	Forestry		■	■	■				■
	Fisheries			■			■	■	
	Agriculture	■	■	■	■	■	■		■
Cultural	Sacred sites				■				
	Archaeological sites				■				
	Indigenous sites and settlement sites				■				■
	Monuments	■			■				■
Green	Trees and gardens	■	■	■	■				■
	Natural landscape systems		■						■
	Open spaces	■	■		■				
	Public parks and squares	■	■	■	■	■	■		■
	Urban agriculture	■	■	■	■	■	■		■

LEGEND:

□ = Negligible Risk—Presents ‘negligible’ risk within the probability of natural variation.

■ = Definite Risk—Presents ‘definite’ risk within the probability of natural variation.

APPENDIX B

EXAMPLE OF QUALITATIVE MEASURES OF CONSEQUENCES

Table B1 provides an example on how to qualitatively estimate the consequences of the identified climate change risk. This approach is suitable for single assets (e.g. a bridge or building) up to regional/state infrastructure. Organizations should develop consequence criteria applicable to their organization and their assets.

TABLE B1

RISK CRITERIA—EXAMPLE OF QUALITATIVE MEASURES OF CONSEQUENCES

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
Insignificant	No change to the adaptive capacity	No infrastructure damage, little change to service	No adverse human health effects	No changes to management required	Little financial loss or increase in operating expenses	No adverse effects on natural environment	No effects on the broader economy
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored	Localized infrastructure service disruption No permanent damage. Some minor restoration work required Early renewal of infrastructure by 10–20% Need for new/modified ancillary equipment	Short-term disruption to employees, customers or neighbours Slight adverse human health effects or general amenity issues	General concern raised by regulators requiring response action	Additional operational costs Financial loss small, <10%	Minimal effects on the natural environment	Minor effect on the broader economy due to disruption of service provided by the asset
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity	Limited infrastructure damage and loss of service Damage recoverable by maintenance and minor repair Early renewal of infrastructure by 20–50%	Frequent disruptions to employees, customers or neighbours. Adverse human health effects	Investigation by regulators Changes to management actions required	Moderate financial loss 10–50%	Some damage to the environment, including local ecosystems. Some remedial action may be required	High impact on the local economy, with some effect on the wider economy

(*continued*)

TABLE B1 (*continued*)

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity	Extensive infrastructure damage requiring major repair Major loss of infrastructure service Early renewal of infrastructure by 50–90%	Permanent physical injuries and fatalities may occur Severe disruptions to employees, customers or neighbours	Notices issued by regulators for corrective actions Changes required in management. Senior management responsibility questionable	Major financial loss 50–90%	Significant effect on the environment and local ecosystems. Remedial action likely to be required	Serious effect on the local economy spreading to the wider economy
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service Loss of infrastructure support and translocation of service to other sites Early renewal of infrastructure by >90%	Severe adverse human health effects, leading to multiple events of total disability or fatalities Total disruptions to employees, customers or neighbours Emergency response at a major level	Major policy shifts Change to legislative requirements Full change of management control	Extreme financial loss >90%	Very significant loss to the environment. May include localized loss of species, habitats or ecosystems Extensive remedial action essential to prevent further degradation. Restoration likely to be required	Major effect on the local, regional and state economies

NOTES:

1 Adaptive capacity relates to the ability of the infrastructure element and/or organization to adapt/change/cope with change in the climate change variable.

2 Financial loss will be relative to the infrastructure element being considered (i.e. a single building, coastal town, rail system). Dollar values need to include replacement cost for the infrastructure item and financial loss/costs relating to the loss of the service provided by the infrastructure item.

3 While the term ‘environment’ can include both man-made and natural systems, in this Standard ‘environment’ is limited to the natural environment outside the asset being considered.

4 Economy refers to the local economy (e.g. town or region), the state economy, or the economy of Australia as a whole. Significance of this measure will depend on the asset being considered.

APPENDIX C

EXAMPLE OF QUALITATIVE MEASURES OF LIKELIHOOD

Table C1 provides an example of how to qualitatively estimate the likelihood of the identified climate change risk. To some extent, likelihood criteria are independent of assets; however, likelihood does have a strong relationship to the climate change event. For example, you may have different likelihood measures for recurrent major catastrophic events, such as severe cyclones, when compared with long term risks, such as increasing sea level and coastal erosion.

TABLE C1

EXAMPLE OF QUALITATIVE MEASURES OF LIKELIHOOD

Rating	Descriptor	Recurrent or event risks	Long term risks
Almost certain	Could occur several times per year	Has happened several times in the past year and in each of the previous 5 years *or* Could occur several times per year	Has a greater than 90% chance of occurring in the identified time period if the risk is not mitigated
Likely	May arise about once per year	Has happened at least once in the past year and in each of the previous 5 years *or* May arise about once per year	Has a 60–90% chance of occurring in the identified time period if the risk is not mitigated
Possible	Maybe a couple of times in a generation	Has happened during the past 5 years but not in every year *or* May arise once in 25 years	Has a 40–60% chance of occurring in the identified time period if the risk is not mitigated
Unlikely	Maybe once in a generation	May have occurred once in the last 5 years *or* May arise once in 25 to 50 years	Has a 10–30% chance of occurring in the future if the risk is not mitigated
Rare	Maybe once in a lifetime	Has not occurred in the past 5 years *or* Unlikely during the next 50 years	May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period if the risk is not mitigated

APPENDIX D

EXAMPLE OF A RISK RATING MATRIX

Table D1 provides an example of a risk rating matrix. It is not a 'one size fits all' set of criteria, and organizations may choose to develop a series of criteria for use in different circumstances. For example, the rating matrix for a hospital may be different to that of the car park associated with it.

Based on the analysis, the organization should then consider the actions to be taken for each risk rating. For example, a particular analysis may show there are 3 extreme risks, 5 high risks, 6 moderate risks and 6 low risks. The organization may then determine that only the extreme and the high risks will be further considered.

Given the inherent uncertainty in climate change projections and the potential for serious or irreversible damage to settlements and infrastructure, it is entirely appropriate that organizations adopt a prudent and conservative risk attitude for risks from climate change. Organizations should also adopt a proactive attitude to maximizing opportunities and benefits associated with a changing climate.

TABLE D1

EXAMPLE OF A RISK RATING MATRIX

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	L	M	H	E	E
Likely	L	M	M	H	E
Moderate	L	L	M	H	E
Unlikely	L	L	M	M	H
Very unlikely	L	L	L	M	M

LEGEND:
E = Extreme risk, requiring immediate action.
H = High risk issue requiring detailed research and planning at senior management level.
M = Moderate risk issue requiring change to design standards and maintenance of assets.
L = Low risk issue requiring action through routine maintenance of assets.

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NOTES

NOTES

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