Adapting to Climate Change

Chapter 8 of *Circles of Sustainability: Tools for Transforming Cities* (draft only)
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The reduction of global greenhouse gas-emissions has since the early 1990s been on the agenda of decision-makers across all levels of government. The central debate has been over how to mitigate anthropogenic or human-made climate change and what targets for mitigation should be required. Much of the recent attention at the international level has focused on the task of the United Nations Frameworks Convention on Climate Change. One key quandary has been how to facilitate a binding greenhouse gas reduction agreement among national governments that could come into force after the Kyoto Protocol expired in 2012. However, climate-change *adaptation* is just as important as mitigation. The Intergovernmental Panel on Climate Change has provided strong scientific evidence that climate change is already occurring and thus has presented a pressing case for simultaneously addressing the impacts of climate change through adaptation. In international negotiations on climate change, this paradigm shift has resulted in the Convention on Climate Change expanding its focus to include negotiations on governance regimes for responding to the impacts of climate change.

Climate-change mitigation and adaptation have thus both become recognized in the policy and practice communities as complementary strategies for responding to climate change. While mitigation and adaptation are commonly distinguished from each other and usually defined as different responses and requiring different processes, they are inherently linked. Adaptation to social and natural forces is a diffuse and difficult task. Originally a concept developed in evolutionary biology, its definition and goals are largely place-based. They require an understanding not only of the impacts that are going to occur in a given place, but also, importantly, of the local fabric of economic, ecological, political and cultural systems. The Intergovernmental Panel on Climate Change definition of adaptation as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects' underlines the context-specific nature of adaptation. The definition does not, however, specify how 'adjustments' in systems should or will occur, or what these systems are. If the different social domains, or the combined socio-environmental 'systems', are considered the locus for climate change adaptation, a clear understanding of the system under consideration is necessary for defining effective goals and devising actions that will work towards these goals within the limits and opportunities provided by that system.

Due to its highly contextual nature, adaptation differs from mitigation in that it mainly results in localized benefits. Although the distribution of adaptation costs across beneficiaries is often contested, the local nature of adaptation benefits can be a significant incentive for individuals, local businesses and local authorities to invest in adaptation measures in their geographic area. For example, tree-planting programs in dense urban areas with limited green space lead to a number of direct adaptation benefits in the city, including improved shading on hot days, improved micro-climate, and a reduction of the urban heat-island effect. Local adaptation approaches that draw on contextual knowledge of economic, ecological, political and cultural conditions can harness this potential, whereas local action on mitigation action is often impeded by concerns about the distribution of benefits and free-riding because localized investment can result in collective global benefits for those who have not invested.

While significant progress on mitigation can be achieved by central regulation through binding intergovernmental and national agreements, adaptation requires place-based approaches that integrate multiple levels of governance, linking strategic top-down guidance with flexible, context-specific responses to local climate-related hazards. The required flexibility exposes adaptation goals to value-based judgement of all the stakeholders and constituents involved, and views can differ substantially regarding what is to be protected from harm, which opportunities are to be exploited, and which vulnerabilities are worthwhile addressing.

One criterion for success in climate-change adaptation therefore is to develop a shared framing of what successful climate change adaptation means in a given context, to enable actors to collaboratively design and

implement effective climate change responses. Knowledge of, and agreement on, key conceptual and operational terms relevant to adaptation processes can help establish such shared framing, but due to the complexity of the problem it can be expected that actions will need to evolve based on flexible and creative thinking. Such complex challenges are thus often labelled as 'wicked problems' and are best-addressed using collaborative approaches involving shared learning across institutions. This chapter describes what it means to adapt to climate change and how it might be done. Along the way the chapter clarifies commonly used terminology and discusses how these different concepts are used in policy development.

The framing considerations of adaptation often remain unacknowledged in political discussions, in choices about planning approaches, and in the selection of assessment methods. Making the terms of adaptation explicit is important for establishing a collaborative process for action. Explicit consideration of a chosen method's framing is also likely to influence the types of adaptation options and pathways considered. The most commonly used methods of adaptation include the following:

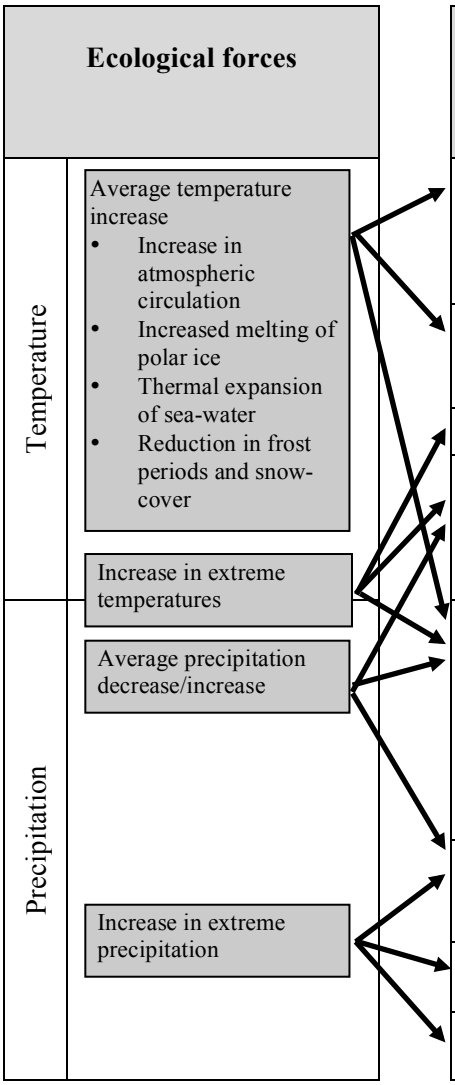
1. *A hazards approach*. 'Hazards' are closely linked to disaster risk-management. This natural disasters frame has been a dominant consideration in policy discussion on climate change. Increasingly broader notions of climatic hazards are being adopted, linked with economic, cultural and ecological trends. For example, it is now recognized that unrestricted population expansion into coastal zones is likely to intensify the consequences of sea-level rise or storm surges. The strengths of a hazards approach is that it tends to draw heavily on quantitative data where available, leading to metrics-based conclusions that are often sought after by policy-developers and decision-makers in order to justify pursuing particular strategies. However, these apparently firm conclusions are actually beset by limits to certainty. It is not an intrinsic problem that climate models are not able to give completely accurate local and regional scenarios for the complex intersection of climatic variables. However, epistemological uncertainty can become a major problem in politically uncertain times. The perhaps necessary act of relocating the inhabitants of hazardous regions and localities, for example, can be resource-intensive and time-consuming, and keeping the uncertainty transparent (a positive process) does not make such actions politically comfortable. This is an example of tensions between critical issues (see Chapter 6).
2. *A risk-management approach*. This is the dominant organizational practice for dealing with many types of uncertainties in local government and the private sector. Central to the notion of 'risk' is the fact of uncertainty and changing perceptions. Risk is defined as the combined product of hazards, exposure and vulnerability, and as such there is a close connection between hazards and risk-management approaches. Risk-assessment and risk-management processes are suitable for organizations of various sizes, can fit well with existing organizational procedures and be readily integrated into existing risk-management systems. However, the approach can lead government to be focused inwardly, often to the neglect of the interests of other departments, external stakeholders and local communities.
3. *A vulnerability approach*. This focuses on who or what will be affected, and in what way. A wide range of possible policy responses to vulnerability is possible. For example, outcome vulnerability relates to the residual impacts—for example, on a habitat, an ecosystem, or a municipality—after all feasible adaptation responses have been taken into account. A contextual framing of vulnerability considers different kinds of vulnerability in the broader context of interactions between climate and society. Good vulnerability assessments can add valuable, bottom-up perspectives for adaptation and be used to build the case for adaptation based on local data and information, thus ensuring that adaptation options are designed in direct response to local needs, enhancing the potential for tangible local adaptation outcomes. Alternatively one weakness in this localizing strategy is that range of vulnerability assessment methods in use makes it difficult to compare the results from different assessments, or to understand the spatial variability of vulnerability beyond the scope of the immediate analysis.
4. *A resilience approach*. The 'resilience' concept originated in the field of ecology as the capacity of an environmental system to absorb disturbance, but is now being translated and applied to human systems. These approaches have the virtue putting the social back into ecological systems analysis. Social resilience can be defined as the capacity of groups or communities to cope with external stresses and disturbances as a result of economic, political, or ecological change. One lineage of this approach puts the emphasis on knowledge systems and adaptive learning as the basis for adapting to change or, better still, transforming for the better. The weakness of the approach derives from its

own double sense of novelty and scientific precision—as if 'resilience' is a more far-reaching concept than 'sustainability' because of when and where it came from.

Each of these approaches has been influential in the development of climate-change assessment methods for good reasons. However understanding how these different assessment methods are framed is important given the role that assessments play in adaptation planning. Framing considerations can determine which government departments are involved and which minister is considered to have responsibility for addressing climate impacts. Clarity about the good qualities and limitations of different assessment approaches will inform the methods used to assess impacts and adaptation responses.

The choice of frame can lead to different types of climate-change assessments. Whichever approach is used, our argument is that adaptation needs to take into account all the domains of the human condition—ecology, economics, politics and culture. Moreover, it needs to develop a reflexive understanding of the intersecting driving forces and critical issues across these domains that complicate any response. The tendency in each of these approaches is to focus on a narrower range than is necessary for dealing with a phenomenon such as climate change that perforce has such social complexity. Hazards approaches, for example, tend to begin with the consequences of ecological forces (see Table 13 below). Risk-management approaches tend to focus on political responses to hazards that potentially could affect the economics of technology and infrastructure or the ecology of habitat, settlements, built-form and transport. Vulnerability approaches tend to focus on local solutions. And resilience approaches tend to emphasize political-cultural responses to ecological change.

Table 13: Examples of Ecological Forces, Events and Critical Issues through the Lens of a Hazards Approach[1]



Events in the ecological domain	Critical issues in the ecological domain	Onset	Duration
Wind storms	Coastal storm damage	Sudden	Short
	Storm damage to built environment and habitats	Sudden	Short
Sea-level rise	Coastal inundation	Slow	Continuous
	Coastal erosion	Sudden or slow	Continuous
Heat waves	Heat stress	Sudden	Short
Bushfires	Fire damage to built environment and habitats	Sudden	Short
Droughts	Drinking water scarcity	Slow	Short to extended
	Irrigation water scarcity	Slow	Short to extended
	Reduced water flows impacting upon river systems	Slow	Short to extended
Torrential rain or extended periods of precipitation	Flood damage to built environment	Sudden	Short
Hailstorms	Impact damage to built environment	Sudden	Short
Thunderstorms	Water damage and fire damage	Sudden	Short

In summary, it is not choice of the method of action that matters most, but firstly, awareness of the strengths and weaknesses of that method. Secondly, whichever framework is chosen, climate change adaptation should be considered a process of continuous responsiveness across all the domains of social life. Thirdly, good adaptation requires good planning. Enacting a good adaption plan, like any plan, entails a comprehensive response: commitment, engagement, assessment, definition, implementation, measurement, and communication (to use the seven-stage process path discussed earlier in Chapter 6). All of these steps are accompanied by ongoing dialogue and learning. In a situation of constrained time and financial resources, the choice of a particular adaptation approach or a combination of approaches will be highly influential in establishing a particular dominant framing for an adaptation process. Ideally, policy-developers and decision-makers should pause and query why a type of approach or method will be applied to any particular adaptation project and ascertain the relevance of the underlying concepts for the purposes of the activity. They should not allow the ideological assumptions of a particular approach to blind them to the need for treating climate change as a holistic issue across all the domains of social life.

(a) Setting Objectives for Adaptation

[1] Adapted from B. Smit, I. Burton, R.J.T. Klein, and J. Wandel, J., 'An Anatomy of Adaptation to Climate Change and Variability', *Climatic Change,* vol. 45, 2000, pp. 223–51.

Setting high-level goals and associated critical objectives for climate-change adaptation needs to be an iterative process so that emerging information on climate-change impacts, the policy context and the activities of stakeholders and constituents can be incorporated at regular intervals. Like all goal statements, the named adaptation objectives need to be achievable and time-bound to be able to effectively drive adaptation processes. However, the definition of time-bound objectives needs to be revisited iteratively in order to accommodate changing climatic or local-context parameters. While a broad vision is needed at the adaptation policy-level (e.g., at the level of state government), more detailed and involved sectoral planning is needed to specify different sector-by-sector objectives, to define concrete targets, and to generate set of appropriate indicators. Setting adaptation objectives also needs to strike a delicate balance between providing clear guidance on the one hand and allowing for a certain degree of flexibility on the other.

(b) How does Adaptation Occur?

Developing a shared understanding of current and future climatic forces and their potential impact—including which forces are critical to a particular location, and what elements of a chosen system are at risk—are essential starting points for adaptation processes that are workable at local and regional scale. This needs to be done in the *assessment stage* while continually re-engaging people through dialogue and learning. Even though it may be impossible to achieve a truly shared public framework for understanding adaptation, making different views explicit paves the way for properly defining the objectives of adaptation and for choosing the processes and tools to be used to achieve these objectives. It makes it more likely that a suite of adaptation measures will be chosen that align with local needs and capacities.

Even after it is agreed that something needs to be done, the evidence suggests that the question of how adaptation is going to occur, the terms of which should primarily developed during a publicly projected *definition stage*, remains an ongoing contentious issue for local and regional-scale adaptation. The 'how' question connects reflections on the purpose of adaptation with basic political decisions on the task to be done. Adaptation planning can take place through various activities leading to different types of *outcomes*, and therefore clarity is needed about the intended outcomes as well as the methods, tools and *processes* used for achieving them. It is useful to briefly examine these two orientations in more detail: adaptation as outcome-driven, and adaption as process-driven.

(c) Adaptation as Outcome-Driven

At the level of international climate negotiations, adaptation is often referred to as being necessary as a direct result of having to deal with the relatively known anticipated negative impacts of climate change. This view follows the argument that adaptation is a way of responding to climate change only because a certain degree of social change can no longer be avoided. When, in these terms, adaptation is framed predominantly as an outcome-driven top-down process, it emphasizes questions of what the desired state of 'being adapted' would look like, what degree of adaptation is technologically possible, and who should be held legally responsible for its associated costs. This outcome-oriented frame also relates well to a gently modified 'business as usual' approach. This approach is described though the metaphor of 'fitting in'; fitting into existing dominant structures. Fitting in, or thin adaptation, tends to occur where the act of adapting is considered to be a comfortably understood and relatively predetermined addition to a given dominant set of existing ways of doing things. Incorporating a few climate-change adaptation considerations into existing land-use practices without fundamentally changing those practices is an example of fitting in.

While a framework that emphasizes outcomes is useful for arguing the case for mitigation, and can provide an impetus for agreeing on adaptation goals, its usefulness is limited when it comes to working towards sets of changing adaptation options, dealing with complex community responses, and devising multi-dimensional adaptation measures. Within such a framework, questions concerning 'how to' act are addressed by turning to conventional planning methods and by using readily applied technologies. Typically in circumstances of outcome-focused adaptation, technological options feature prominently in measures to reduce or compensate against hazards and risks (thus invoking only one perspective of just one domain—the technology and infrastructure perspective). This focus on achieving relatively predictable outcomes is one of the reasons why technology-and-infrastructure responses, such as building sea-walls and flood-barriers, are often treated as the first option and favoured over alternative 'soft' adaptation options. The validity of an outcome-oriented top-down framing of adaptation lies in developing a better understanding of what different futures may look like, for example, as part of scenario-planning exercises (see Chapter 9), but its weakness lies in not being adequately handle complexity.

(d) Adaptation as a Process-Driven

Adaptation framing which focuses on process tends to place greater emphasis on adapting to climate-change impacts by adopting a systems perspective. Such framing recognizes that adaptation is a continuous process of interaction between human social 'systems' and the environment. Adaptation is thus characterized more by ongoing social learning than outcomes. Process-oriented framing of adaptation inevitably emphasizes the role of people and institutions, their evolving capacity of effectively dealing with climate change impacts, commonly referred to as 'adaptive capacity'. It tends to work across the range of non-technological and technological adaptation measures.

While bringing global protocols for climate-change adaption down to local, urban and regional levels can certainly prove useful for decision-making, they need to be complemented by more reflexive bottom-up approaches to adaptation planning. This approach acknowledges that effective adaptation needs to be deeply embedded in local knowledge. Framing climate-change adaptation as a learning process is useful in providing answers to the question of how adaptation is going to occur at local level, and therefore should be considered a vital and self-conscious component of any operational adaptation framework. In embracing a process of institutional and individual learning for climate-change adaptation, local decision-makers are enabled to explore a broad range of adaptation options that will become more sophisticated as their adaptive capacity increases. It is strongest when coupled with a qualified version of outcome-driven adaptation.

Section 1.02 Cross-Domain Options for Adaptation

Decision-makers and local communities can come up with an infinite number of adaptation measures to achieve stated objectives, and the broad range of options available can often be overwhelming to practitioners. Table 14 below provides a typology of possible climate change adaptation measures, which can help understand broad options available to policy-developers, both formal and informal. In keeping with the *Circles of Sustainability* approach, four inter-related categories of adaptation measures are proposed: namely, ecological measures such as re-establishing self-generating natural protection zones; economic measures, ranging from technological responses to financial schemes; political measures, for example, institutional capacity-building and regulatory frameworks; and cultural measures, for example, learning and communication tools. All of these measures can be implemented at different levels of government using a combination of policies and regulations, market-based and non-market-based incentives, and different projections or cultural visions that go beyond self-interest and the need for material incentives.

(a) Table 14. Types of Adaptation Measures Across the Different Domains of Social Life

Domains	**Perspectives**	**Examples of Local and City-Wide Responses**
Ecology	Materials and Energy	• Setting up distributed renewable energy systems less prone to extreme weather problems.
	Water and Air	• Reclaiming natural verges and flood plains along waterways to mitigate the inundation of unsuitably located buildings.
	Flora and Fauna	• Planting native trees and plants to increase the resilience of urban parks and gardens in the face of climate extremes.
	Habitat and Settlements	• Building sea-walls, albeit back from the present immediate shore-line, in anticipation of potential sea-level rise and storm surges.
	Built-Form and Transport	• Retrofitting buildings to better protect people from extreme heat.
	Embodiment and Food	• Establishing robust, seasonal, local food production, including through urban

		agriculture and aquaponics.
	Emission and Waste	• Improving the capacity of urban drainage systems.
Economics	Production and Resourcing	• Securing supply lines of basic commodities.
	Exchange and Transfer	• Providing funds for conducting local climate-impact assessments.
	Accounting and Regulation	• Spreading climate risks equitably across insurance providers.
	Consumption and Use	• Setting up bulk-buying schemes for domestic rainwater tanks.
	Labour and Welfare	• Recognizing that in the aftermath of extreme weather events people might need time off work for home renewal.
	Technology and Infrastructure	• Installing water metres to monitor and help address wasteful water use.
	Wealth and Distribution	• Providing compensation for those who are required to move their places of abode away from hazard zones.
Politics	Organization and Governance	• Changing the organizational structure of municipalities and governments to increase the ability to respond to climate change.
	Law and Justice	• Setting restrictive development controls in coastal hazard zones.
	Communication and Critique	• Disseminating up-to-date information on extreme weather events via social media.
	Representation and Negotiation	• Inviting community groups and local leaders to decide priorities and participate in adaptation planning processes.
	Security and Accord	• Anticipating and planning for security problems due to complex emergencies.
	Dialogue and Reconciliation	• Conducting scenario planning exercises that explicitly attempt to reconcile needs and limits.
	Ethics and Accountability	• Acting upon support for climate-change refugees.
Culture	Identity and Engagement	• Re-orienting identity away from high mass-consumption products.
	Creativity and Recreation	• Engaging artists to symbolically represent the consequences of climate change
	Memory and Projection	• Projecting scenarios of possible adaptation futures
	Beliefs and Ideas	• Generating public discussions and debates about different adaptation measures and their variable impact.
	Gender and Generations	• Responding to the potential of the elderly and the vulnerable to be affected by extreme heat and cold periods.
	Enquiry and Learning	• Training local government staff on climate-change methodologies.
	Health and Wellbeing	• Anticipating measures needed to respond to increased water-borne and insect-transmitted diseases.

Decision-making on local adaptation measures requires some form of qualitative or quantitative evaluation of the various adaptation options available. For each identified climate-change impact, a range of options exist that could potentially be equally effective in combating negative climate-change impacts, or alternatively, harnessing new opportunities. For example, to decrease the urban heat-island effect in densely built up areas a combination of the following options may be found appropriate:

- Increasing shading of buildings and sealed surfaces; for example, by planting trees;
- Increasing evapo-transpiration in the area, for example, by converting sealed areas into green spaces and constructing water features;
- Ensuring better ventilation of the area; for example, by creating building corridors that enable cooler air flow into the area; and
- Rendering buildings in reflective colour to decrease heat absorption into thermal mass.

Each of these measures comes with an associated financial cost, a specific minimum time-line for implementation, and a series of secondary environmental and social effects that will inform public opinion and decision-making. In the example of the heat-island effect, adaptation metrics can be employed to assess cost-benefit ratios of the various options available *ex ante,* under current and projected climate change. In the context of mid-term to long-term adaptation and whenever non-technological adaptation is included in the equation, it is, however, far less straightforward to establish which adaptation options are most suitable, because many of the potential benefits may be unknown and lie in the future. While cost-benefit analysis can be a suitable tool for many technological adaptations (for example, building or upgrading of infrastructure to protect from flooding), it has significant methodological limitations when it comes to measuring the expected costs and benefits of non-financial factors.

Ex post evaluation of adaptation measures is similarly difficult, in particular in terms of providing guidance for adaptation to future extreme events, which occur infrequently, at irregular intervals, but with potentially devastating impacts. Current extreme events may provide a significant trigger and incentive for adaptive action, which are likely to also reduce future vulnerabilities. It may be prove politically difficult, however, to justify and agree upon large-scale investment into costly adaptation measures for preventing future catastrophic impacts, in particular when an empirical evaluation of the suitability and effectiveness of measures already implemented cannot be ascertained within standard planning and political cycles.

This conundrum points to the limited suitability of cost-benefit analyses for guiding effective climate change adaptation at the local and regional levels. Cost-benefit analyses and similar economic tools need to be supplemented and informed by additional qualitative studies, for example exploratory research investigating past and present local practice of dealing with climate change. Such climate analogues can provide important contextual information on how socio-ecological systems are likely to respond to particular adaptation measures.

Furthermore, the limitations of applying a cost-benefit approach towards evaluating different adaptation options highlight the need for applying alternative metrics to the costing of climate change impacts that are able to accommodate non-financial costs and take into account contextual economic parameters. The shortcoming of economic assessment tools also reiterate that a focus on the process aspects of adaptation may provide a more flexible way forward in adaptation planning, rather than relying mainly on substantive adaptation outcomes that have been determined using conventional economically rational decision-making.

Different measures need also to have different *temporal* scopes, laying out steps between short-term and long-term implementation. They need to be developed with a specification of different *spatial* scopes, for example, local, municipal, regional or national). And they require awareness of the status of the *epistemological* scope whether they are being devised in reaction 1. to a documented and known existing climate impact, 2. during the occurrence of a changing impact, or 3. in anticipation of an (expected) impact in the distant future. Using these three dimensions of temporal scope, spatial scope, and the timing of action in relation to an impact as descriptors

(b) Avoiding Maladaptation

In the absence of a large evidence base on what constitutes good adaptation, adaptation efforts should therefore at a minimum endeavour to avoid any ‘bad’ adaptations, including the following:

- Measures that increase greenhouse gas emissions or other adverse ecological consequences;
- Measures that disproportionately burden the most vulnerable social groups;
- Measures that come with high opportunity costs—that is, high economic, ecological, political or cultural costs in comparison with sound alternatives;
- Measures that reduce the incentive for actors to adapt—for example, by increasing the reliance of actors on others' actions or the activities or different levels of government; and
- Measures that create a path dependency—that is, measures that adopt trajectories that are difficult to change in the future due to high costs involved in such change.[2]

Such maladaptations not only pose a risk of significant ecological, economic, political and cultural costs, they can also undermine the support of key adaptation actors.

Section 1.03 Risk Assessment Methods

In the previous section we have provided an overview of what we consider to be key issues in the context of adaptation framing. In this section we elaborate upon two common approaches used in adaptation processes and unpack the conceptual frames inherent in these approaches. The first, risk assessment, as part of a risk-management approach, provides a process for dealing with uncertainty. Although risk can be quantified using various formulas, qualitative or perception-based approaches often inform risk assessments. This occurs in particular when political or cultural systems are the subject of risk assessments. Standard risk-assessment matrices are used to assess the likelihood and expected consequences of a climate change impact under different scenarios, resulting in ratings of 'low', 'medium', 'high' or 'extreme' risk, which indicate the level of priority with which a risk should be treated (Table 15 below).

(a) Table 15. Priority Risk-Rating Matrix

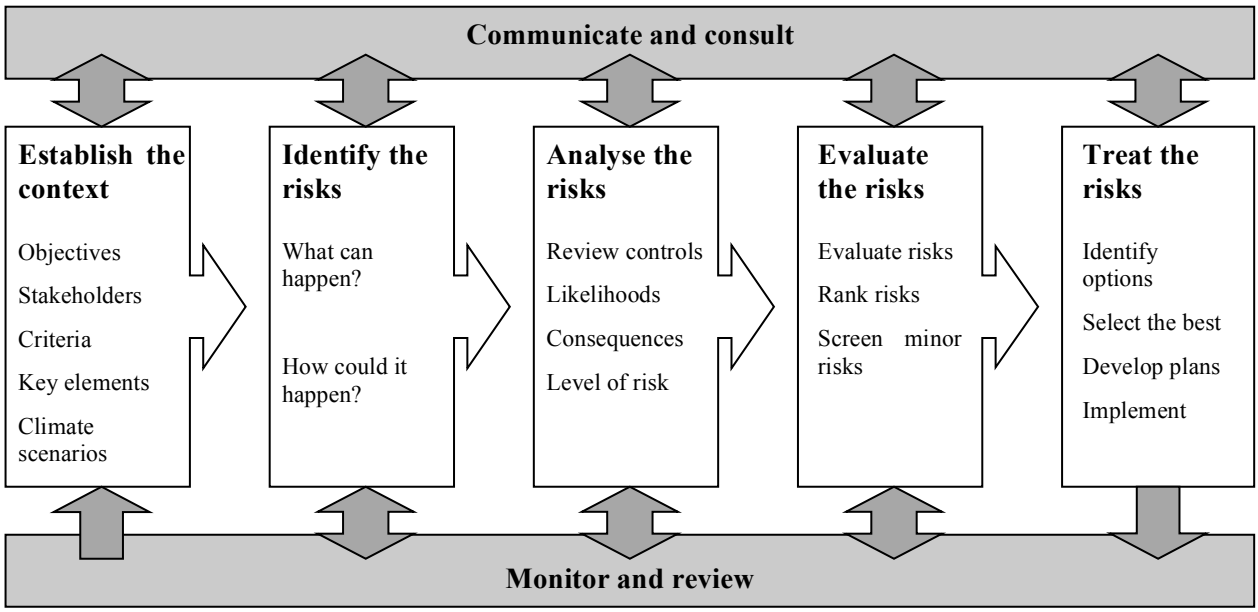
Likelihood	**Consequences**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Source: Australian Government (2006).

The Australian Government's Climate Change Impacts and Risk Management guide suggests a sequential process for climate risk assessment and management is suggested, consisting of five major steps (Figure 5 below). This relies on the active participation of stakeholders: establishing the context, identifying, analysing and evaluating climate change risks, and treating the risks by identifying adaptation options. The process, although sequential, relies on ongoing monitoring and evaluation. In many ways it is a simpler version of the *Circles of Social Life* process pathway laid out earlier in Chapter 6.

[2] J. Barnett and S. O'Neill, 'Maladaptation', *Global Environmental Change,* vol. 20**,** 2010, pp. 211–13.

(b) Figure 5: Steps in the Risk-Management Process



Source: Australian Government (2006)

As part of establishing the context for climate risk-management, the guide recommends carrying out a scoping exercise, which includes setting clear objectives, identifying key stakeholders, setting success criteria to be used for evaluating the outcomes of the risk-management process, as well as identifying key elements at risk and choosing one or several climate scenarios that will inform the process. To ensure the validity of the process and its outcomes, it is critical that a diverse group of key stakeholders participates in the process. Part of the initial scoping process is also developing context-specific scales that define different levels of risk likelihood and consequence. These likelihood and consequence scales are to be developed based on strategic organizational objectives (referring back to the understanding that risk means a threat to an organization achieving its objectives). They usually build upon both qualitative and quantitative elements.

The second step in the process involves identifying climate-change risks that various key elements (or exposure units, in the language of impact assessment) will be exposed to under different climate-change scenarios, using participatory brainstorming and data-gathering techniques. Qualitative cause-effect statements can help clarify why a particular issue is considered a risk. Risk analysis is conducted mainly qualitatively, by assigning each risk a level of priority based on the likelihood of the risk eventuating under different climate change scenarios and its expected consequences. The likelihood and consequence scales developed during the first step are applied here. Where possible, qualitative risk analysis and priority rating should be supported by quantitative studies that explain why a particular likelihood or consequence rating is appropriate.

During the third step, assigned priority risk-ratings are evaluated by ensuring they are consistent with one another and match the stakeholders' interpretation of the local context in which they are operating. This assessment process, consisting of risk identification, analysis and evaluation, then forms the basis for exploring options for 'risk treatment'—that is, the development, selection and implementation of adaptation measures that reduce the levels of risk.

Climate risk-management processes are suitable for organizations of various sizes, from community organizations to government departments. Due to their reliance on qualitative data and expert knowledge, engaging a suitable group of stakeholders from different backgrounds is essential to the effectiveness of the adaptation options developed in the final stage of the process. One of the strengths of risk-assessment approaches to climate change is that they can fit with existing organizational procedures and can readily be integrated into existing risk-management systems and structures. A risk-based approach to climate-change assessments enables stakeholders to establish likely cause-effect type links between projected climatic

changes and the operational context in their department, their community or their organization. By getting stakeholders to engage with projected changes in climatic parameters through understanding how these relate back to organizational objectives and services, ownership for adaptation processes can be created. This is critical for ensuring that adaptation measures derived from risk assessments are meaningful, feasible and effective.

One limitation in the context of governmental organizations is that the implementation of risk-assessment processes tends to be focused inwardly, often to the neglect of external stakeholders, services and activities that are considered peripheral to an organization. In the local-government sector, for example, a risk-management approach to climate change typically focuses on corporate risk—that is, risks that threaten the key objectives of the organization. Such assessment processes, to be conducted properly, need to broaden to consider climate risks to the community (for example, via organizational objectives that relate to service delivery, community satisfaction and well-being). Organization assessments can thus be a suitable entry point to a more holistic approach to adaptation.

Another limitation of simply templated risk-management processes, such as the one outlined, is that it relies to a significant extent on the views of individual stakeholders. In this context, it is important to acknowledge that an ideal-world scenario of equal representation and engagement of key consitutents from different disciplinary backgrounds is rarely achieved in adaptation processes. It is more likely that some individuals will be more involved in the process than others, some will be able to dominate the discussions more than others, and that some constituents may choose not to participate or express their views. Therefore, careful and professional facilitation is required for any climate-change assessment, including climate risk-assessment processes, and transparency about who is involved in what role needs to be achieved early in the process.

Section 1.04

Section 1.05 Vulnerability Assessment Methods

Vulnerability assessment has emerged as a common practice in climate change adaptation processes, and, due to a lack of standardization and the multi-faceted nature of the concept of vulnerability, it is implemented in many different ways, using a range of definitions of vulnerability and various assessment methods. The following sections are an attempt to provide an overview, acknowledging that it is difficult to do full justice to this diversity.

(a)

(b) Objectives and Methods

Conducting a vulnerability assessment is seen by many as a critical component of climate change adaptation processes at the local level, as it can elicit knowledge about the expected distribution of impacts across a system. Vulnerability assessments typically consist of assessing the characteristics of a vulnerable system, the type and number of stressors affecting that system, and the effects these have on the system. The widely used IPCC definition of vulnerability suggests that assessing vulnerability becomes meaningful and practicable only if it is conducted only in relation to a specified hazard, a range of hazards, or a specific system. As opposed to climate impact-assessment and risk assessment, vulnerability assessment is less rigidly defined, and processes labelled as vulnerability assessments reveal a great diversity in approach and methodologies used.

Over the past decade, vulnerability assessment methodologies have moved from an exclusive focus on the biophysical environment and questions of physical vulnerability towards the inclusion of, and a greater focus on, an assessment of the social vulnerability of segments of the local population. Different types of vulnerability assessment continue to co-exist, however, reflecting the broad applicability of the vulnerability concept across different social and environmental phenomena. A biophysical vulnerability assessment may, for example, focus on evaluating the impact of increasing average night-time temperatures on the evapotranspiration of trees in an urban park. A social vulnerability assessment of heat stress will identify groups within the population that are particularly under threat of suffering health and well-being impacts during a heat wave. A combined biophysical and social assessment may analyse, among other factors, the combined effects of changing evapotranspiration patterns of urban trees and the effect of heat fatigue due to warmer night-time temperatures. In many vulnerability assessment methodologies, four elements stand out as particular relevant:

1. Focus on a *vulnerable system*, which forms the scope for analysis and assessment. Depending on the disciplinary perspective and the scoping process, these typically comprise a coupled socio-ecological system, a social system or sub-systems (such as a social group), or a particular geographic region or area.
2. Consideration of the *elements at risk* within the system. Examples of typical elements at risk to climate change impacts are human lives, flora and fauna species, habitats, cultural and religious values, buildings and infrastructure.
3. Identification of a particular *hazard*, which denotes a potentially damaging influence on the system of analysis. Hazards are sometimes differentiated into discrete hazards, or perturbations, and continuous hazards, or stress/stressors.
4. A *temporal reference*, which scopes out the time-frame used for vulnerability assessment. Applying an explicit time-frame is particularly relevant in the context of climate-change adaptation, where impacts, to a large extent, lie in the future.[3]

A technical paper informing the UNDP's Adaptation Policy Framework[4] serves as an example of how these elements are translated into a method for assessing social vulnerability, consisting of five discrete steps (Table 16). Similar to other types of assessment approaches discussed above, a definition phase is outlined, focusing predominantly on specifying a conceptual framework and a workable definition for vulnerability. The identification of vulnerable groups (Step Two) focuses on the scoping of system boundaries, including which groups are exposed to hazards.

This is followed by an assessment of sensitivity of the system and identified vulnerable groups, i.e. gaining an understanding of how climate hazards translate into climate impacts, risks and disasters. Importantly, the approach uses the identification of the drivers of current vulnerability to assess how future vulnerability is likely to be determined, and what role processes of autonomous adaptation can play in the reduction of vulnerability (step four). In a final step, assessment outcomes inform adaptation policy and decision-making.

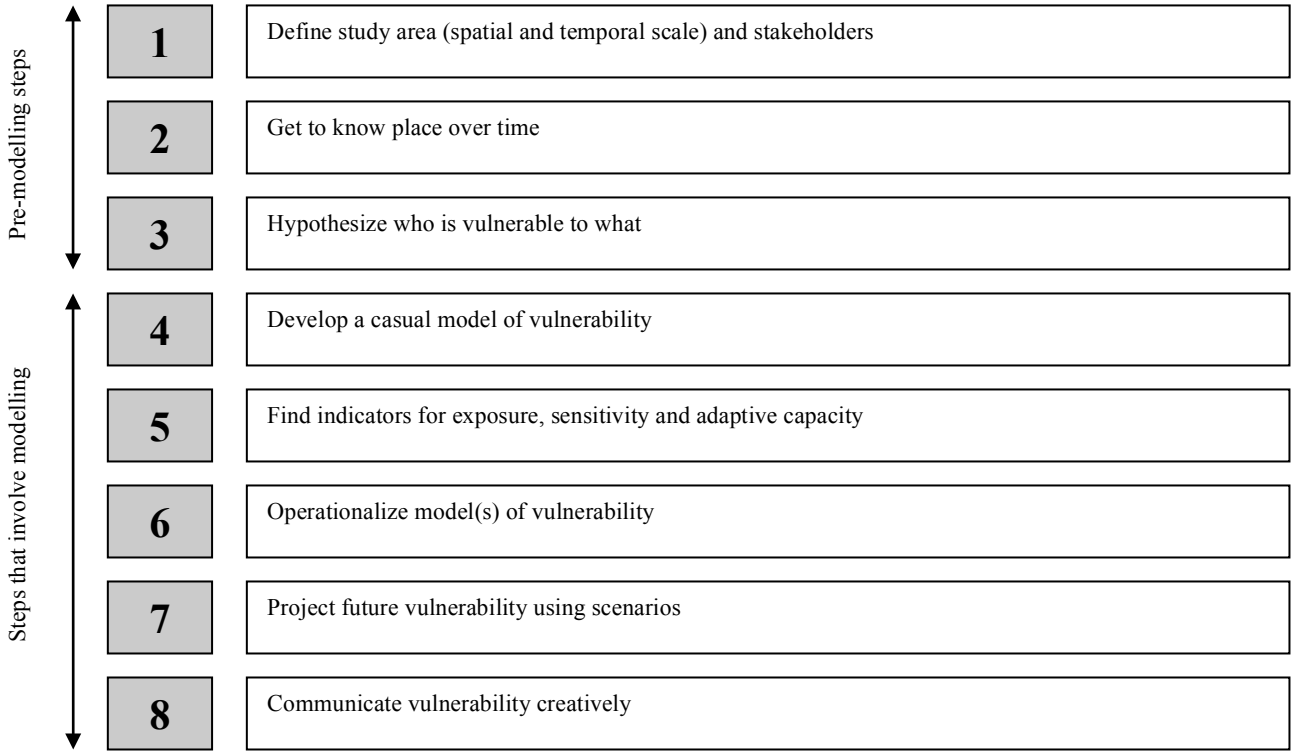
Table 16. Five-Step Approach to Vulnerability Assessment[5]

No.	Objective of activity	Description
1	Structuring the vulnerability assessment: Definitions, frameworks and objectives	Clarifying the conceptual framework and analytical definitions of vulnerability being used for the assessment.
2	Identifying vulnerable groups: Exposure and assessment boundaries	Defining the system chosen for the assessment, including who is vulnerable, to what, in what way, and where. System characteristics to be defined include sectors, stakeholders and institutions, geographical regions and scales, and time periods.
3	Assessing sensitivity: Current vulnerability of the selected system and vulnerable group	Developing an understanding of the process by which climate outcomes (e.g., hydrological and meteorological variables) translate into risks and disasters. This includes identifying points of intervention and options for response to vulnerability.
4	Assessing future vulnerability	Developing a qualitative understanding of current drivers of vulnerability in order to better understand possible future vulnerability, including ways in which planned or autonomous adaptation may modify climate risks.
5	Linking vulnerability assessment outputs with adaptation policy	Relating vulnerability assessment outputs (2-4 above) to stakeholder decision-making, public awareness and further assessments.

[3] H.-M. Füssel, 'Vulnerability: A Generally Applicable Conceptual Framework for Climate Change Research', *Global Environmental Change,* vol. 17, 2007, pp. 155–167.
[4] B. Lim and E. Spanger-Siegried, eds, *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*, Cambridge University Press, Cambridge, 2005.
[5] T.E. Downing and A. Patwardhan, in B. Lim and E. Spanger-Siegried, eds, *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*, Cambridge University Press, Cambridge, 2005.

One alternative extended approach to vulnerability assessment puts greater emphasis on qualitative aspects and the need for embedding vulnerability assessment as a bottom-up process in local knowledge and traditional 'wisdom'. Step Two in the eight-step model outlined in Figure 6 (below) therefore emphasizes the need for getting to know the study location (assuming an external researcher is conducting the assessment). Also, this approach explicitly mentions the use of exposure, sensitivity and adaptive-capacity indicators, which constitute a model of vulnerability used for assessment (Steps Five and Six).

Figure 6: Eight-Step Model for Global Change Vulnerability Assessment[6]



Using various approaches to vulnerability assessment, numerous studies have tried to develop composite local vulnerability indices, to assist communicating assessment outcomes, with mixed results. For example, overlaying vulnerability indicator data collected during an assessment with demographic information can produce maps of relative vulnerability and its variation across space.

(c)

(d) Strengths and limitations

Vulnerability assessments can add a valuable, bottom-up perspective to climate change adaptation processes. Their strength is that they build the case for adaptation based on local data and information, thus helping ensure that adaptation options developed during planning processes can be designed in a way that they directly respond to local needs. If implemented in a participatory way, drawing on the knowledge and views of various local stakeholders, vulnerability assessments have the potential to pave the way for tangible local adaptation outcomes. Also, through the analysis carried out as part of vulnerability assessments, future climate impacts become directly linked to current contextual drivers of vulnerability (e.g., broader socio-economic processes affecting a particular place), hence enabling the identification of 'starting points' for adaptation by focusing on current vulnerability.

Vulnerability assessment is most useful for analysing how current climate variability and projected climate change impacts may affect different populations (or other system components), in different ways. Depending on the approach used the can add a quantitative or qualitative layer of local knowledge and information to decision-making processes, focused on the needs of vulnerable groups or system components. Where vulnerability assessments mainly produce qualitative data on the expected consequences of climate change,

[6] D. Schröter, C. Polsky and A. Patt, 'Assessing Vulnerabilities to the Effects of Global Change: An Eight Step Approach', *Mitigation and Adaptation Strategies for Global Change,* vol. 10, 2005, pp. 573–95.

their outputs often don't meet current needs for an evidence-base to decision-making, for example in relation to costly infrastructure investments. This limitation, however, applies to other types of assessments as well, and purely quantitative assessment outputs, on the other hand, can suggest a degree of certainty that doesn't reflect the complex and variable nature of climate change.

The heterogeneity of the various vulnerability assessment methods used also means that it is difficult to compare the results from different assessments, for example in order to understand the spatial variability of vulnerability. Maps of relative vulnerability, which are popular with planners and decision-makers in outcome-orientated organisations, suggest that vulnerability is quantifiable. While such maps can be a useful visualization tool for communicating projected climate change impacts at local level, they contain a range of assumptions inherent in the methodology, including significant degrees of uncertainty, which need to be discussed with stakeholders, constituents, and end-users.