Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

A Toolbox-Based Decision Framework for Climate Change Adaptation

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Author

S.G Oldfield[1]

Affiliation

1. MWH New Zealand Ltd., PO Box 9624, Te Aro, Wellington

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1. Introduction

This document presents a framework within which robust and defensible decisions can be made to manage the effects of climate change on urban built environment and infrastructure.

1.1 Background

In an uncertain future, where climate change effects have the potential to change long-term decisions about the planning and development of the urban and built environment, councils and other organisations are faced with some fundamental questions:

- Which climate change effects should be of most concern? (Scoping issue)
- Where are the needs for action most pressing? (Prioritisation issue)
- What actions provide the best solution? (Optimising the adaptation response)

There is inherent uncertainty in predicting the timing and location of future effects of climate change, and in the context of this Toolbox, the effects on the urban and built environment. Geographical and demographic differences mean that the answers to the above questions are very much regionally dependent.

In uncertain situations such as these, there is a real danger of over-compensating as well as under-compensating for climate change impacts that are still not well understood at a local scale.

This document attempts to provide a general framework in which priorities for responding to climate change issues can be established by councils, and others, when faced with making decisions with limited budgets and an uncertain future. It includes a roadmap of the staged process underpinning the Toolbox and explains where the various Toolbox tools may guide this process.

2. The Planning Decision Hierarchy

Robust planning decisions that will stand the test of time, including the effects of climate change, need to be made on a firm basis of knowledge. However, given that our current knowledge is incomplete, major uncertainties remain.

Figure 2.1 gives a schematic representation of a risk-centred view of a hierarchical basis for robust planning which is achieved through:

- Synthesis of the available science and data using investigation and modelling;
- Application of risk assessment principles to gain an understanding of the uncertainties and vulnerabilities; and
- The assessment of alternative adaptation options.

Because our understanding of climate change impacts continues to evolve, there will also be an ongoing requirement for the management of risks, planning and adaptation.

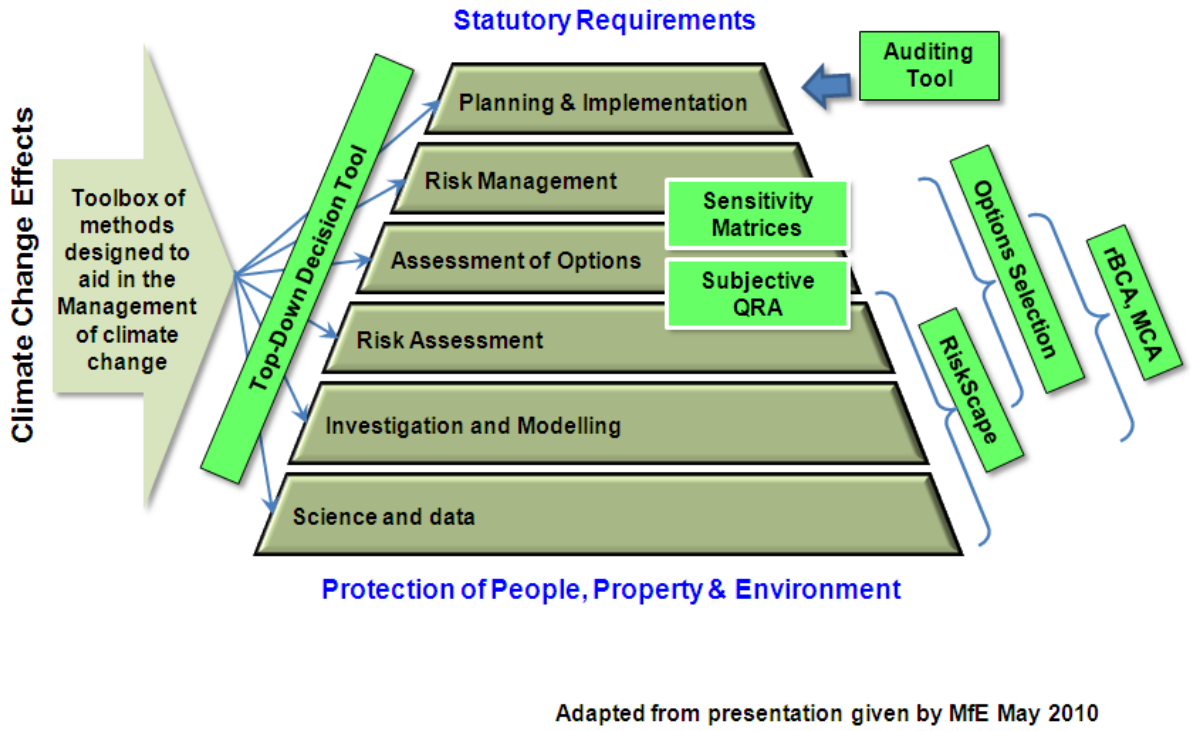

Figure 2.1: Planning Foundations Diagram for Climate Change

A selection of the various Toolbox tools are labelled in Figure 2.1 (green boxes) to show where they are intended to assist councils and others in developing robust planning decisions.

It is not intended that the diagram necessarily implies a linear development of knowledge from science to planning. Rather, it is intended to show that planning decisions must be founded on a firm foundation of current knowledge and options evaluation (based on the values and knowledge of the day), and that risk management provides the 'glue' which holds the process together.

In particular, risk-based methods provide a means of assessing options and prioritising effort to obtain the best gains by:

- Explicitly accounting for uncertainty;
- Focusing attention where the need for action is greatest;
- Assessing the effectiveness of alternative adaptation options; and
- Determining the tolerability of residual risk.

3. Making Decisions

It is generally accepted in modern democratic society that decisions are based on a consensus view, which usually involves compromise. One consequence of this is that often a solution will not completely satisfy everyone. However, this is usually seen as preferable to taking a major decision that satisfies one group at the expense of others. Acceptance of this viewpoint is implicit in the following discussion.

3.1 An Overview of Decision-Making

Taking a general view, there are three essential elements to the decision-making process (see Figure 3.1):

- The people or stakeholders involved, which includes both the decision-makers and those affected by the decision;
- Relevant studies and data which inform the decision; and
- A process, or framework, within which decisions are made.

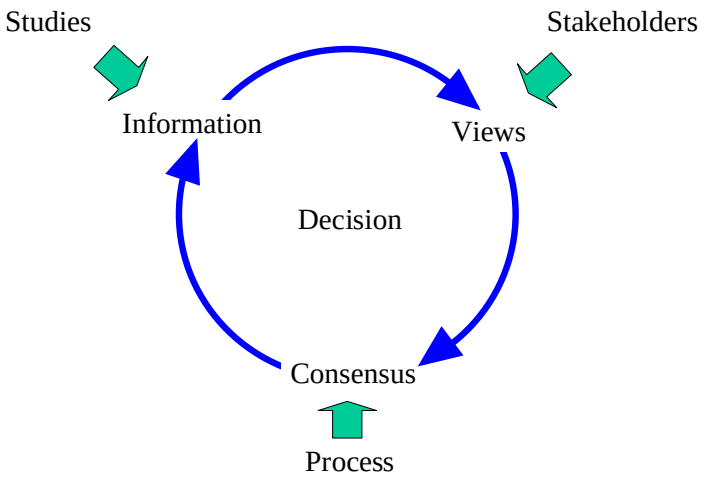

Figure 3.1: Components of the Decision-Making Process

Figure 3.1 shows that decisions are generally made through an iterative loop or cyclic process of refinement as more is learnt about the problem to be solved. At some stage, however, it is necessary to 'break out' of the loop in order that a decision can be made, despite the lack of complete information. Provided the decision process is seen as robust and fair, the process should provide a justifiable mechanism for 'breaking out' to allow a decision to be made.

The focus of this document is on the decision-making process itself. Details of the information gathering and consultations performed to support making the decisions, while important, are only discussed insofar as they are relevant to the themes presented in this document.

3.2 Why Are Formal Decision Processes Used?

Employing formal methods or protocols to help explore what is best and reasonable could be seen as constraining decision-making if the method lacks flexibility. On the other hand, making decisions within a formal framework provides some balance to the competing views.

A formal process provides the essential rationale and traceability of decisions that are eventually made. The robustness of these decisions may then be explored and, if independent objective information can be obtained, further tested to corroborate the decision. Validation may be achieved, for example, by learning from what works well and what does not as the decision outcome is implemented, thus allowing some adaptation to local circumstances.

In order to formulate judgements in situations of high uncertainty, such as those generated from climate change, it is important that a formal decision-making process is used that will stand up to scrutiny, and from which findings can be derived that are reasonably acceptable[1] to all.

Accepting that there is a clear case for the proposals to go ahead but the associated benefits and disbenefits affect different groups, what constitutes 'best' and 'reasonable' needs to be explored. This may be achieved through a process of information gathering, discussion, consultation and decision-making. Such decisions are, however, constrained by engineering practicalities, environmental, social and

[1] What constitutes reasonable is difficult to pre-define; it may only be possible to define after the different view points are debated. It should also be clear that different groups and individuals will have a different understanding of what is reasonable.

economic[2] constraints. The exploration, discussion and consultation of the issues are, therefore, inseparable from the decision process itself.

Agreeing on and adopting a formal decision process provides a means of tracking and recording the steps leading up to a decision. It facilitates the dissemination of information supporting (or negating) the proposed outcome and assists understanding of the decision by others not directly involved. It also allows the decision to be challenged and tested, for example in a consent application. Furthermore, it allows decisions to be revisited at some later date, with possible revision in light of new information.

4. Some Key Principles in Decision-Making

Taking a risk-based approach to decision-making is a major theme that runs throughout the tools and guidance given in the Toolbox. This perspective assumes that the best course of action is the one that maximises the chance of achieving a desired outcome (or minimises the chance of failing to meet specified outcomes).

Nevertheless, and despite the importance of risk as the 'glue' in the decision-making processes, it is rare that risk will be the only metric for establishing priorities. Other principles have their role to play in achieving the best or most desirable outcome, such as:

- A multi-valued approach, in which risk is only one of a number of metrics which need to be considered in seeking 'optimal' solutions;
- A 'least regret' approach, seeking out and implementing the easy win, or win-win solutions;
- Seeking sustainable solutions which, as far as is practicable, do not limit future needs and directions;
- Adopting a measured but precautionary approach – decisions that err on the side of caution have built-in 'safety factors'; and
- Using a gradual or staged approach to provide for greater flexibility to adapt as circumstances become clearer over time.

In many respects, all of these principles will apply to some degree and are not incompatible with the risk-based approach developed here.

[2] Economics is part of the equation because ultimately the consumer must pay for the developments, either directly through higher bills or indirectly through taxes.

The above principles are simply stated here as they are not central to the themes being developed in this publication. However this does not mean that these, and other, principles are not important. The interested reader is referred to the guidance documents for more information [for example; MfE 2007, MfE 2008 and MfE 2010].

5. Developing a Decision Framework for Climate Change Adaptation

A decision framework has been developed that provides for a balanced and justifiable prioritisation of sustainable adaptations to climate change and which is flexible to change. The current level of uncertainty surrounding the timing and geographic location of future climate effects requires this framework to be risk-based. It incorporates formal decision-making processes, for the reasons outlined above, and employs a Toolbox approach, because the diversity of decisions to be made is not conducive to a 'one size fits all' approach.

While there are many ways that priorities for action could be established, it is likely that a staged and risk-centred approach, involving a successive narrowing down and refinement of the issues of concern, will be an important part of setting priorities. With climate change singled out for attention, an example three-staged approach is illustrated in Figure 5.1.

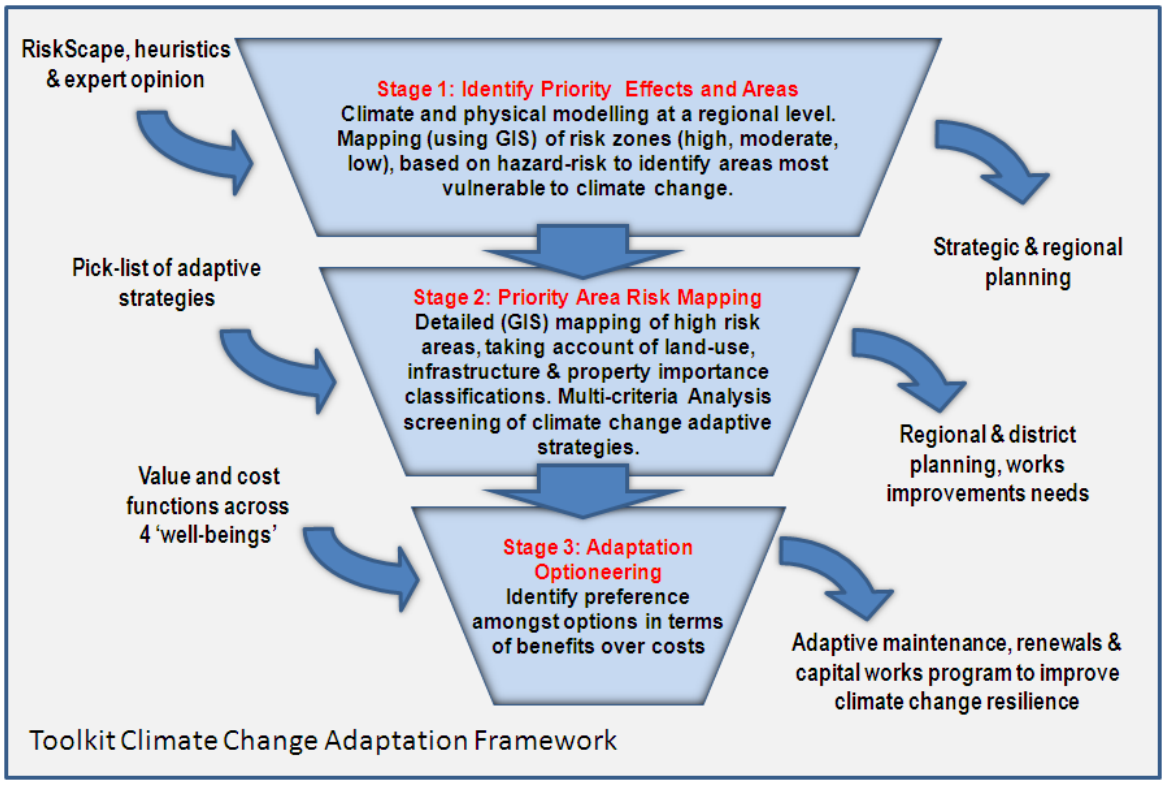

Figure 5.1: Staged Approach to Decision-Making for Climate Change Adaptation

The stages in Figure 5.1 may be summarised as follows:

Stage 1 involves an assessment of priorities across all the climate change effects of relevance for the geographical region of interest. This is to identify priority climate change effects and areas most vulnerable to these effects.

Stage 2 involves risk mapping of priority (high risk) areas for the selected climate change effects, as identified from Stage 1.

Stage 3 involves identifying preferences among alternative adaptation schemes to address the priority climate change effect (identified in Stage 1) and the risk identified in the priority locations (identified in Stage 2).

A variety of methods and tools has been provided in the Toolbox to assist establishing priorities at each stage, namely:

Stage 1: decisions on which climate change effects are of concern and the affected areas of the built environment can be made using the Council Policy and Plan Auditing Tool [Tool 1.5], the Sensitivity Matrix Prioritisation Tool [Tool 1.6], and the Top-down Decision Tool [Tool 4.6].

Stage 2: decisions on risk mapping of priority areas and interpreting the outcomes can be made using the RiskScape Tool [Tools 3.2 & 3.3], using the Subjective Quantified Risk Assessment Tool [Tool 3.5], or the Multi-criteria Assessment Tool [Tool 4.5].

Stage 3: decisions can be made using the Optioneering Tools [Tools 4.2 & 4.8], the Multi-criteria Analysis Tool [Tool 4.5], or the Standard or Rapid Cost Benefit Analysis Tool [Tools 4.4 & 4.3, respectively].

5.1 Adding Structure to the Basic Decision Cycle

Figure 5.2, which is based on a simplification of the Analysis of Interconnecting Decision Areas (AIDA) methodology, adds a little more detail and practicality to the basic decision cycle given in Figure 3.1.

The AIDA process was developed in the 1980s to articulate the key elements of planning decisions, and is just one of many decision frameworks that could be used. It is chosen here because it is consistent with the core requirements of analysis and consultation on options, as promulgated in the Resource Management and Local Government Acts and in MfE guidance.

AIDA has also been selected for the Toolbox because it links the basic three elements of the decision cycle with the practicalities of making decisions on climate change effects that inherently involve uncertainty. For example, mean temperature projections in 50 to 100 years time (MfE, 2008) span the range of *very confident* (direction of change), through *moderate confidence* (magnitude of change) to *low confidence* (spatial/seasonal variations).

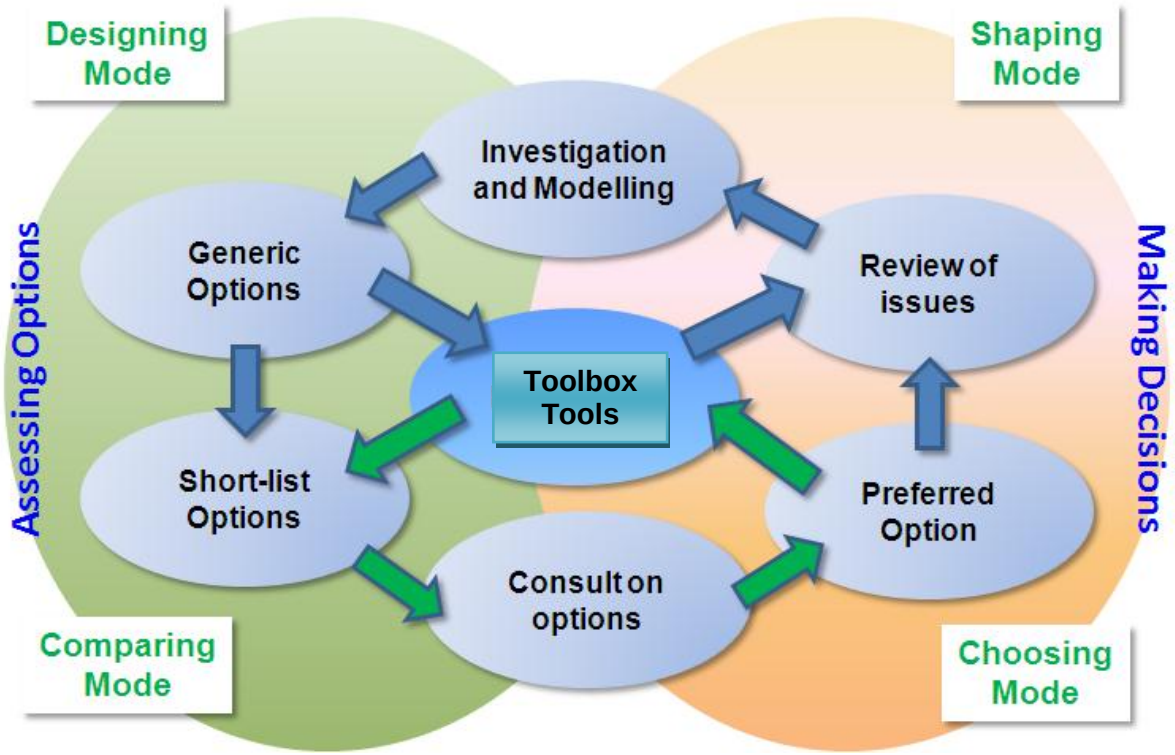

Figure 5.2: The Simplified AIDA Process: Stage 3 – Choosing the Preferred Adaptation Option

In the AIDA process, the "Designing" and "Shaping" modes provide the "Information" in the decision cycle of Figure 3.1. "Views" in the decision cycle (Figure 3.1) are obtained through the "Comparing" and "Choosing" modes of the AIDA process. The Toolbox tools (centre of hub) provide the means of arriving at a consensus on which solutions are best, given the information available and views expressed.

Figure 5.2 is cast in the role of assessing climate change adaptation options to derive a preference (priority) amongst alternatives, given limited information and possible conflicting views about what is preferred. However, the same process can be applied at the other stages (see Figure 5.1) of the decision process.

Thus exchanging the word "Options" used in Figure 5.2 for the words "Climate Change Effects" makes the above AIDA process diagram relevant to the prioritisation of the effects of greatest concern (Stage 1 in Figure 5.1). Alternatively, exchanging the word "Options" used in Figure 5.2 for "Geographical Locations" makes the AIDA process relevant to prioritising and risk mapping the geographical locations of particular concern (Stage 2).

It can be seen that the basic decision cycle (Figure 3.1) and the AIDA process (Figure 5.2) do not have a starting point, recognising that decisions are not developed from a 'clean sheet'.

The various Toolbox tools provide a range of principles and methods that can be used to assist the evaluation of priorities, the identification and shortlisting of adaptation options and a means of determining priorities at each the three stages identified in the Framework illustrated in Figure 5.1.

This is further explained in Section 6 which describes a 'Roadmap' of the Toolbox-based decision framework for assessing climate change, showing links to the most appropriate tools for the user to select depending on their position in the process. Further information on the selection of tools is given in other sections of the [Toolbox Overview].

6. Toolbox Roadmap Decision-Making Framework

Figure 6.1 provides a generalised 'Roadmap' indicating where the various Toolbox tools may be used in the three stage framework (Figure 5.1) discussed above.

In Stage 1, the Sensitivity Matrix [Tool 1.6] may be used, for example, to establish the climate change impacts to urban infrastructure and services that are of most concern.

In Stage 2, RiskScape [Tools 3.2 and 3.3] and Subjective Quantified Risk Assessment [Tool 3.5] may be used to identify geographical areas were the climate change impacts might be most significant.

At Stage 3, Rapid Cost/Benefit Evaluation [Tool 4.3], Multi-Criteria Analysis [Tool 4.5] and the Top-Down Decision Tool [Tools 4.6] may be used to assist in the selection of options.

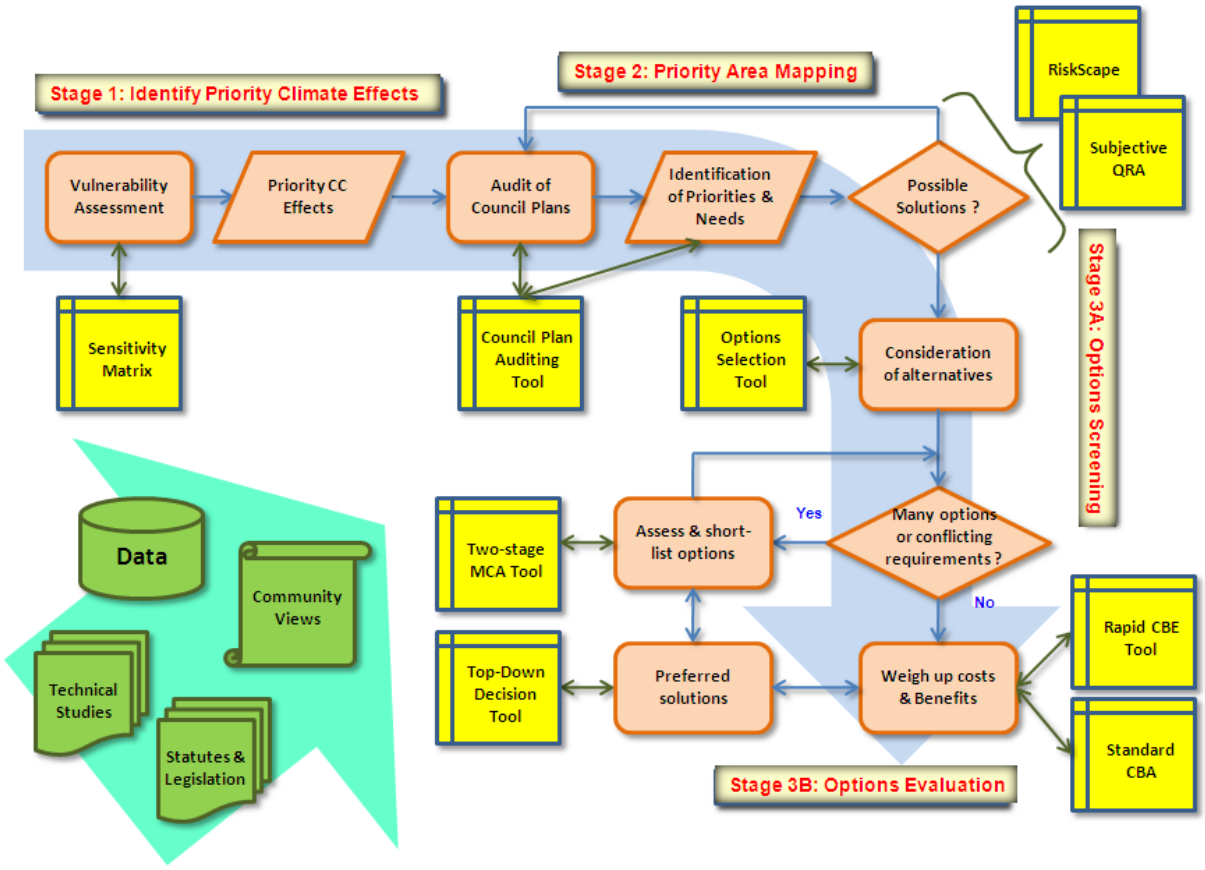

Figure 6.1: Toolbox Roadmap Decision-Making Framework

It is not intended, nor it always necessary, to start at the beginning (Stage 1) of the Roadmap illustrated in Figure 6.1. In some situations, depending on prior work, it is possible to apply the tools without completing earlier steps. However, there could be a danger that later steps may be compromised as a result. For example, inadequate consideration of alternatives may potentially result in delays in achieving the required consents and substantial re-work.

Figure 6.1 is used in the various linkage documents included in the Toolbox to provide signposts for the user to understand the next steps that should be taken.

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