Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

Message 5.3: Climate Change – the Long Term View

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1. Introduction

1.1 Background

The concentrations of greenhouse gases in the atmosphere are continuing to rise despite international efforts currently aimed at mitigation or reversal of current trends, and despite some major local and national successes in reducing or offsetting emissions. Stabilisation of greenhouse gas levels may be many decades in the future.

In the meantime, the effects of climate change are beginning to be experienced. These effects are likely to become more apparent in terms of average parameters of climate (e.g. temperature, precipitation) and frequency and severity of weather-related events over time, before stabilisation occurs. There is a lag in the atmosphere's adjustment to small changes in greenhouse gas concentrations – in other words, a significantly delayed relationship between cause and apparent effect. This has already been experienced through the delay in observed effects from changes which began primarily with the industrial revolution.

Thus, in simple terms, regardless of the effectiveness of mitigation, unavoidable climate change effects are expected for decades, but more likely centuries ahead, and adaptive responses are necessary.

Sea-level rise, as a consequence of climate change, through thermal expansion of the oceans and melting of glaciers and ice sheets around the globe, is a specific effect anticipated to be of very long duration, if not permanent. For this effect, the parameters at issue are the rate and the eventual extent of the rise.

1.2 Purpose of Tool

This 'Message' Tool provides a summary of some of the concepts and principles relating to the time dimension that need to be kept in mind when developing approaches, examining possibilities and options and making decisions on adaptations to climate change in the urban setting.

2. The Exposure of Urban Environments

Some urban environments are particularly exposed to the risk of climate change effects. The very factors that led to the location of early settlements, such as the availability of fresh water and fertile soils, or ease of trade along rivers and by sea, now have consequences that could not have been foreseen.

In particular, coastal settlements are likely to be exposed to sea-level rise, and in some localities, increased wave action and greater storm surge. Settlements on flood plains may be exposed to increasing frequency of flood events and increasing flood peaks and durations. Depending on their location and sometimes on their scale, settlements may experience water shortages, and/or increased fire risk, and citizens may be exposed to greater temperature ranges and/or more extreme weather events over time.

However, urban patterns are very slow to change and much urban infrastructure, including building stock, transport systems and services ranging from the 'three waters'[1] to electricity distribution and waste disposal are expected to have long life-times (with or without maintenance and/or upgrading).

In New Zealand, based on past patterns, current urban areas and existing buildings could be expected to accommodate much of next century's population. Some specific urban elements, such as built heritage, increase in perceived value over time.

Urban environments which involve highly fragmented land and property ownership, such as those in New Zealand, have particular issues in relation to existing investment, which is an exacerbating factor in terms of resistance, or a slow response, to change.

The IPCC's November 2011 SREX Summary Report[2] makes two very important points when considering timeframes. Firstly it notes that:

> *"development practice, policy, and outcomes are critical to shaping disaster risk, which may be increased by shortcomings in development".*

Secondly it explains that:

> *"attention to the temporal and spatial dynamics of exposure and vulnerability is particularly important given that the design and implementation of adaptation and disaster risk management strategies and policies can reduce risk in the short-term, but may increase exposure and vulnerability in the longer term".*[3]

The SREX report also notes that climate change-related extremes are only one factor affecting risk. However, *"if disasters occur more frequently, and/or with greater*

[1] Water supply, wastewater management and drainage (stormwater) systems.

[2] IPCC, 2011: Summary for Policymakers. In: Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C. B., Barros, V., Stocker, T.F., Qin, D., Dokken, D., Ebi, K.L., Mastrandrea, M. D., Mach, K. J., Plattner, G.-K., Allen, S. K., Tignor, M. and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] Citing the example of dyke systems (flood protection bunds and walls, and coastal hard protection structures) which provide immediate protection for existing settlements, but which may encourage a settlement pattern that increases risk in the long-term.

magnitude, some areas will become increasingly marginal as places to live or in which to maintain livelihoods".

Urban environments, with their highly concentrated populations and existing investments, and anticipated future development, require particular attention in terms of space and time. Spatial aspects of urban areas are addressed at local level through planning processes. Temporal aspects require equal consideration in any decision made by local authorities.

The range of Tools and case studies in this Toolbox give examples which show how the time dimension can be integrated into decisions relating to climate change.

3. Key Considerations in Terms of Time

3.1 Duration of the Urban Element

There are three key types of questions to be explored when making a decision on a matter relating to change in an urban environment. These questions are not new or unusual, as predictions which relate to the effectiveness or usefulness of the investment or policy decision are always taken into account[4].

These three types of questions can be expressed simply as follows:

1. What is the expected lifetime of the decision? Does it usher in a permanent modification to the urban environment, such as a rezoning of land from urban to rural, or provide for a costly fixed asset with an anticipated long lifetime[5], or is the nature of the asset such that it can be expected to be rebuilt, upgraded or modified over time?[6]

2. How likely are the effects of climate change to be experienced in the lifetime of the decision, and what type and extent of risks and potential effects will result from this exposure?

3. What is the cost and degree of difficulty in incorporating a response to the potential climate change effects in the decision to be made now? How readily can adjustments be made in the future?

[4] For example, many infrastructure decisions include consideration of future demand, population growth, and anticipated changes in expectations or lifestyle (e.g. greater use of private cars or, higher water consumption for personal use).
[5] For example, regional landfills, water supply dams, major bridges, major substations.
[6] Many reticulated services come into this category, with the ability to upsize or increase their efficiency. Buildings may come into this category, but key structural elements may be difficult to modify and often have a longer than expected lifetime.

Generally, the more permanent the change, the more important it is to build in long-term robustness and resilience to climate change effects. As noted in most guidance material, including the Toolbox examples, aspects relating to climate change may not greatly exceed the natural variability that is already taken into account, so additional robustness may be achieved at a relatively small cost.

It is now accepted in New Zealand that planning for new urban areas (for example, avoidance of areas prone to natural hazards such as flooding or landslips, the general layout, provision of natural drainage systems and green spaces) should be considered as permanent.

The most reasonably reliable information over the longest term that can be obtained should be taken into account in such planning. IPCC-based scenarios should be used, and need to be interpreted locally.

There are several sources of appropriate advice [see Message 5.2: Keeping up-to-date on climate change information and adaptation].

Key controls over private development decisions that will also affect the future 'liveability' of an area under long-term climate change patterns should also take a very long-term view. For example, protection of drainage paths and minimum floor levels in a flood hazard area.

More detailed asset planning decisions require consideration of context, costs and ability to modify (scalability). Examples are given in this Toolbox of how appropriate information can be compiled and worked through. The planning life for community assets varies, but usually exceeds 30 to 50 years in the urban environment. Those responsible for analysis and decisions on alternatives should transparently address climate change aspects and effects, including the time dimension.

3.2 Risks of Over- or Underestimating the Effects

As a general statement, it is less risky to overestimate than to underestimate the effects of climate change in making decisions in the urban environment. This is because there is generally less certainty about *when* predicted effects will occur, than that they will actually occur, and it is as well to be prepared in advance.

Furthermore, as many adaptive actions have co-benefits, overestimating the effect may help achieve other beneficial outcomes, regardless of the timing of the climate change effect.

Usually, the accuracy of the time variable is less crucial than other considerations – such as practicability and/or cost.

The range of examples in this Toolbox, and other examples in the New Zealand literature, shows how the time component can be integrated into decisions, including the use of tools such as risk assessment and cost-benefit analyses.

It should also be recognised that urban systems are complex, and those who live in them will continually be seeking means of improving their living conditions and avoiding risk to investments and to communities.

Lastly, it can be expected that adaptation options will be continuously under review and that some additional means of reducing risk exposure may come to light over time. This does not mean that adaptive responses should be delayed – rather it means that a continuous cyclical approach of action, monitoring, learning from experience and further responsive action can limit the implications of an inadvertently conservative decision.

3.3 The Importance of a Long-Term View

One particular issue which has been identified in the IPCC's 2011 SREX report referred to above, particularly relates to long-term considerations.

Where a decision is made on the basis of managing long-term climate change effects, it is important that corporate knowledge is retained within a local authority about the reasons for the decision and the nature and extent of the risks the decision was based upon.

In urban systems there is the potential that subsequent decisions can be made without a full understanding of reasons for an earlier decision, or without full policy interpretation. This can result in outcomes which can be counter-productive.

For example, a decision to move towards a higher level of protection in a floodplain by increasing the height of stopbank to achieve protection from, for example, a 1% AEP flood to, for example, a 0.25% AEP flood (present time), specifically to account for increasing risk due to long-term climate change events, may lead to subsequent decisions, such as to reduce emergency response readiness or to enable intensification of development in reliance of this apparently higher level of protection. When the basis for the change is analysed, the change may simply be to retain the status quo in terms of risk over a 20 to 40 year period, for example, and the subsequent decisions should have recognised that purpose.

While emergency response readiness can be readily increased to address a growing risk, a decision to allow intensification of development is effectively permanent, and will result in more people and property being exposed to the same level of risk that the earlier decision was seeking to address.

Local authorities should ensure that their documentation and policy advice takes account of the reasons for decisions in the long-term.

As explained in [Message 5.2], it is important to regularly update knowledge about climate change over time. Subsequent decisions should always be made in the light of the most up-to-date information, as well as any changed policy context.

4. The Specific Case of Sea-Level Rise

Introducing climate change considerations into any decisions on the urban environment must rely on projections of future local conditions relating to weather events or shifts in long-term climate-related conditions. As each circumstance is different, there is no 'right' or 'wrong' approach. Best practice should be followed relying on risk assessment and taking into account other decision criteria.

However, sea-level rise is much more pervasive and predictable than other climate change effects. For this reason, a national approach in terms of predicted future sea levels is now being applied in New Zealand, with the government recommending specific levels as follows:

> *"The Ministry [for the Environment] recommends planning for the following projection of future sea-level rise:*
>
> - *For planning and decision timeframes out to 2090-2099, a base value sea-level rise of* ***0.5m relative to the 1980-1999*** *average be used* ***along with*** *an assessment of potential consequences from a range of possible higher sea-level rise values. At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8m relative to the 1980-1999 average.*
>
> - *For planning and decision timeframes beyond the end of this century, an additional allowance of 10mm per year be used."*[7]

It should be noted that this recommendation is not scaled in terms of time. In other words, there is no suggestion that consideration of a shorter timeframe is appropriate in decision-making in coastal locations: there is an underlying assumption that a long-term view needs to be taken for all decisions[8].

The New Zealand Coastal Policy Statement (2010) requires a similar 100-year minimum timeframe for addressing climate change-related risks, including

[7] Ministry for the Environment recommendation as at September 2011 – see MfE website.
[8] The introduction to the above MfE quote refers to *"planning decisions on infrastructure made by councils and engineers"*, but is not limited to such circumstances.

exacerbated and new climate change-related risks (Policy 24). In situations where there is existing significant development, consideration of a range of options to reduce risk in such circumstances, including managed retreat, will be needed (Policy 27). The base approach is to *"avoid redevelopment, or change in land use, that would increase the risk of adverse effects from coastal hazards,"* including *"locating infrastructure away from areas of hazard risk where practicable"* (Policy 25).

Sea-level rise is a matter that is receiving particular attention from the IPCC, and improved global information can be expected in the 5th Assessment Report (AR5 – completion date for Working Groups scheduled for late 2013/2014.[9])

5. References

IPCC (2011). Summary for Policymakers. In: Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C. B., Barros, V., Stocker, T.F., Qin, D., Dokken, D., Ebi, K.L., Mastrandrea, M. D., Mach, K. J., Plattner, G.-K., Allen, S. K., Tignor, M. and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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[9] See http://www.ipcc.ch/pdf/ar5/ar5-leaflet.pdf