Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

Message 5.5: Climate Change, Community Resilience and Sustainable Development

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1. Introduction

1.1 Background

The idea of sustainable development emerged in the mid 1980's, particularly with the publication of "Our Common Future" in 1987[1]. Sustainable development was first described as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*.

"Our Common Future" raised awareness of concepts of human wellbeing and basic needs, continuity from one generation to the next, and also concepts of scarcity and resource limitations, and environmental stewardship. Not only did it confirm earlier recognition that the world is a highly interconnected place, but it advanced the ideas that present generations (regardless of where on the planet they are) are responsible for each other's wellbeing, and that there are also responsibilities for the wider environment, and for the wellbeing of future human generations.

Various agencies have finessed the concept of sustainable development, so that it is more accessible to the wider public. For example, the UK government's programme towards sustainable development is to ensure *"a better quality of life for everyone, now and for future generations to come"*.

In the past 25 years, the concept of sustainable development has become all-pervading, with concepts of sustainability and ethics embedded internationally through numerous protocols and agreements, and through the behaviour of corporate and political organisations. Local government has a key role in this. Arising from Agenda 21[2], the role of local government in sustainable development has been significant and ongoing. Local government is in a position to maintain strong links with its communities such as businesses, organisations such as NGOs, civil society organisations and residential and other physical communities within the urban and rural fabric.

Much effort in sustainable development has gone towards increasing efficiency of use of resources, improving resource protection, minimising wastefulness and modifying lifestyles. This is to help resources last longer, assist transfer to improved technologies or renewable resources, and to reduce resource consumption. Other elements of sustainable development have focussed on community development and local management of the environment in which people live their daily lives.

[1] World Commission on Environment and Development, London, Oxford University Press, 1987.
[2] The outcome of the United Nations Conference on Environment and Development (UNCED), Rio de Janiero, 1992. Agenda 21 is an international plan for sustainable development, with action proposed at every level from the UN to local communities.

Climate change is associated variously with industrialisation, human mobility and land use practices. It has introduced a new strand of issues to be faced, both by present and future generations. Responses to climate change, both adaptive and in terms of mitigation[3], are inevitably by definition part of sustainable development. For example, Climate Change and Energy[4] was one of four key areas of UK central government policy and action towards sustainable development in the first decade of this century. The New Zealand government's approach remains similar in scope, although not expressed in such terms.

1.2 Purpose of Tool

The range of tools in this Toolbox has provided ideas and examples of means of:

- identifying climate change effects that are likely to affect any particular urban area;
- determining the risks that such effects pose, taking into account factors such as the existing situation and the specific urban context; and
- taking into account timeframes and costs and benefits in decisions.

Earlier Messages in this Toolbox (Tray 5) have addressed the need to take into account the best available information [Messages 5.1 and 5.3], and for keeping up-to-date on knowledge about climate change and adaptation [Message 5.2]. The need to consider alternatives and to take a balanced approach in climate change responses has also been emphasised [Message 5.4].

This final 'Message' outlines concepts of sustainability and community resilience in climate change responses. It looks at the need to respond to changes in ambient climate indicators, to predictable climate extremes, and to unpredictable extreme events. It emphasises the need for continuing effort in adaptation to such changes and of finding ways to reduce the impacts of climate change effects at the community and individual level.

2. Integrating Climate Change Adaptation into Sustainable Development

In pursuing the idea of sustainable development, communities are already taking many steps and making many decisions that will assist in facing climate change.

For example, actions to insulate buildings to reduce fossil fuel or electricity consumption and/or improve people's physical wellbeing when indoors are also an

[3] Reducing the causes of climate change, primarily through reducing greenhouse gas emissions.
[4] With the stated aim of *"reducing greenhouse gases, whilst at the same time preparing for the climate change that can't be avoided"* (UK Directgov website, 2012).

action that will moderate (at household and workplace level) temperature extremes which may be experienced with more severity and/or greater frequency in the future.

Well-insulated buildings are likely to have a longer practical life, and therefore are more likely to contribute to the stock of built resources available for future generations to use or modify for their own needs. However, to achieve this latter sustainable development concept, the buildings would also need to address other climate change-related risks. For example, they should also be outside areas that are prone to future flooding (taking into account enhanced risk due to climate change), or adapted in some other way to address future flood risk.

Climate change effects can best be approached within a sustainable development context as 'add-on' considerations to actions the community or the local government agency would already be taking. As yet, there are very few circumstances where climate change adaptation is the sole initiator, or the sole reason for a decision. Rather, it is often an exacerbator in circumstances that a community is already seeking to address. An example would be the oversizing of piped drainage systems, or their removal and replacement with higher capacity swales, or providing additional height in a floodbank protection system. However, in some circumstances, as discussed below, climate change readiness may already justify certain decisions or actions which would otherwise not be taken.

Sustainable development climate change adaptation actions are currently predicated on the ability to achieve co-benefits, or 'win-win' situations. However, in some areas, particularly in the growing area of promotion of community resilience, climate change is not simply a contributor of co-benefit justifications for planning action – it may be the key driver. This is further discussed in Section 3 below.

2.1 Planning for Changes in Ambient Climate Indicators

Climate change is sometimes portrayed as a range of slow long-term trends across a number of key climate indicators. This is one valid basis for long-term decisions – for example, gradually increasing average annual temperatures or changes in average annual and seasonal precipitation. It is these trends that are most readily measured and expressed (although there are acknowledged complexities with such information), and are considered to be the most reliable outputs of global climate modelling processes.

Projected changes to the average climate, within a certain range and acknowledged variability, is most readily able to be integrated into decisions on sustainable

development. In the urban environment, more so than in productive rural areas[5], there are limits on the usefulness of such information in terms of adaptation[6].

However, knowing that an urban area (often already a 'heat island') is going to become warmer, can lead communities and decision-makers to protect urban green spaces and to engage in, for example, tree planting in streets to ensure summer shade in 20 to 100 years time. In such an example, recognition of future benefits as a result of climate change may align with a community's current desire to improve the visual amenity of a built urban environment, and may help off-set additional annual maintenance costs.

Similarly, layout and orientation of subdivided lots and building design may be validly considered in terms of managing future warmer average temperatures, and approaches to water supply (particularly storage systems) should now be taking into account anticipated changes in typical seasonal catchment rainfall patterns.

As advised in [Message 5.3], a long-term view should be taken when decisions will have long-term consequences. Consideration of gradually shifting ambient climate indications is an important (but not the only) aspect of climate change to be taken into account when considering adaptation in any urban community.

2.2 Planning for Climate Change within 'Normal' Variability

Climate variability within the 'normal' range is also an important consideration in terms of sustainable development, as noted in the MfE's Guidance Manual for Local Government. Decisions that relate to 'predictable' extremes are often less simple than those that relate to long-term ambient changes.

Cyclical patterns, such as the El Niño phenomenon, are a normal part of the climate, and these long-term variations are frequently perceived as extremes by the communities they impact upon. Climate change is generally expected to modify such cycles and potentially alter the pattern of extremes associated with them, with different implications in different parts of the globe.

Accepted methods of accounting for current and future extreme events, within the bounds of the predictive capacity of global models, and the ability to translate them into regional effects, are available. This information assists in estimating, e.g. flood risk or water shortage risk, as demonstrated in a range of Toolbox Tools. This same approach is used in planning for sustainable development, including by local government in making planning and engineering design decisions.

[5] Where average soil temperature may, for example, control the productive efficiency of some crops, or average temperatures limit the presence of some pest species.
[6] This is because urban systems tend to be designed to meet high-risk situations, e.g. the 5% AEP rainfall event, or the 1% AEP river flood level.

Even in apparently straightforward situations, such as pipe sizing for stormwater systems, determining road locations and levels on a flood plain, or bridge design, making allowance for future climate may have significant implications to the service provider. More complex situations such as evaluating requests for renewal or intensification of urban development in a known flood-risk area raise many more complex considerations.

Many relevant considerations may be in the nature of 'intangibles', which cannot readily be translated into dollar terms. In this case, techniques such as comparative risk assessment [see Tool 3.5] or multi-criteria analysis [see Tool 4.5] may be needed. Another consideration, relevant in terms of sustainable development, is how the long-term costs and benefits (both tangible and intangible) will be spread across the community (public/private and between different groups), and the circumstances of those who will carry the risk in the long term (even into future generations).

Sustainable development concepts consider a level of security and protection in the urban environment from 'normal' extreme events – the acceptable level to be determined with community input – but that some exposure to risk would remain. The nature and consequence of the risk needs to be established, and the opportunities, costs and benefits of managing the residual risk considered.

2.3 Unpredicted Extreme Events

One of the issues around sustainable development and adapting to climate change, identified as early as the mid 1990's, is the difficulty of identifying and preparing for events which are beyond the range of what could normally reasonably be expected. Such events have in the past sometimes been referred to as "storminess" although it is recognised now that they are better expressed as extreme events.

IPCC's 2011 SREX report[7] acknowledges that *"low-probability high-impact changes associated with the crossing of poorly-understood climate thresholds cannot be excluded, given the transient and complex nature of the climate system"* (in the context of comparing the climate at the end of the 20th century to that which is likely at the end of the 21st century, regardless of the scenario on which it is based).

Such events are not well-characterised or predicted by global climate models. Some appear to be associated with the shifting of climate bands further from the equator and other large-scale circulatory mechanisms (such as the bands in which cyclones and monsoons typically occurred in the past) and the consequent exposure of land masses and populations to circumstances they have not formerly experienced. Others may be

[7] IPCC, "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation", Summary Report, November 2011.

associated with complex interactions between ocean, land mass, and atmosphere, and the levels of energy and humidity in the atmosphere.

Extreme and unpredicted daily temperatures (potentially leading to heat waves), droughts, rainfall events, wind events, and the consequences of floods, water shortages and fires are all being experienced globally to an unprecedented extent, as noted in the IPCC's 2011 SREX report[8]. Further increases in these extreme events are projected over the 21st century[9].

New Zealand is thought to be somewhat buffered from such events due to its location and the moderating effect of the large volume of ocean which surrounds the country. However, it is not immune from ex-tropical cyclone tracks or very localised events such as tornadoes.

As such events are not predictable in terms of location, time and severity, and their implications relate primarily to the community and to its physical and economic resources as much as to natural resources (the latter which may recover naturally), it is difficult to adapt to them in conventional physical ways.

While adaptation to expected 'normal' variability may, as described in Section 2.2, assist in a response to such circumstances, adaptation responses to unpredictable low frequency/high impact events relies primarily on a range of responses that overlap with the residual risk end of planning for normal variability under climate change. These types of responses are discussed in Section 3 below.

2.4 Planning for Sea-Level Rise

Message 5.3 noted that sea-level rise is being addressed with a greater level of national guidance than other potential climate change effects. This is because of its pervasive nature, New Zealand's long coastline, and the country's past patterns of coastal development and associated high exposure of affected communities and infrastructure. It is also due to a high level of confidence in predicting its rate of increase globally (due to the process of thermal expansion of sea water; there is less confidence in the upper end of the sea level rise range due to the complex processes associated with the melting of ice sheets), and international concern that the effect will be difficult to mitigate as oceans have a low ability to respond rapidly to future reductions in atmospheric concentrations of greenhouse gases.

Sustainable development in coastal areas now involves consideration of sea level effects in association with weather events and associated effects, and the interaction of sea level with river and groundwater systems. Planning for climate change adaptation

[8] Ibid
[9] See IPCC 2011 SREX Summary Report fact sheet.

in this area is likely to involve the complete range of Tools that are available in this Toolbox (plus many others). However, in areas of existing non-climate related coastal risk including areas of erosion, subsidence and tsunami risk, climate change adaptation benefits can be counted alongside other sustainable development considerations when decisions are being made.

3. Resilient Communities

Resilience is defined in the IPCC's 2011 SREX report[10] as *"the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structure and functions".*

Resilience is the counter to vulnerability, which is described as *"the propensity or predisposition to be adversely affected"* and exposure, which is described as *"the presence of people, livelihoods, environmental services and resources, infrastructure or economic, social or cultural assets, in places that could be adversely affected"*[11].

Considerations of resilience effectively provide a 'reality check' in terms of preparedness to face residual risk. This includes risks of events of low probability and high potential impact whose occurrence and severity cannot be readily predicted. (See [Tool 3.1] for a discussion on residual risk and other risk principles in the context of climate change).

Resilience implies that communities will have taken the steps to avoid or mitigate[12] the foreseeable climate change risks that they are exposed to (acknowledging that the ability to achieve avoidance or appropriate levels of mitigation is influenced by a very wide range of factors from the physical to the social and economic).

The range of circumstances that have led to the current level of resilience of a community have often not involved active (or even conscious) decisions. The concept of sustainable development, however, means that conscious and considered decisions do need to be made, now and in the future. Sustainable development also implies that while individuals may be able to provide for some of their risk management, and fend for themselves for short periods in an emergency, there is a level of community responsibility when addressing residual risk.

[10] Ibid
[11] Both definitions are from IPCC's November 2011 SREX Summary Report.
[12] Mitigate in this context means a partial response to a climate change effect – or a step towards avoidance of an effect. It is not to be confused with the mitigation referred to in footnote 3, which relates to addressing the causes of climate change, mainly through reducing the atmospheric levels of greenhouse gases.

Resilient communities will make use of a wide range of adaptive responses. Figures 3.1 and 3.2, reproduced from the IPP's 2011 SREX report[13] show some basic relationships.

Figure 3.1 shows in simple form the relationship between weather and climate events (natural and climate change-related), community vulnerability and exposure, and the propensity for disasters to occur despite adaptation. Emergency (or disaster) risk management is the main effective way of dealing with residual risk that extends beyond a community's adaptive ability.

Figure 3.2 indicates the many areas and types of responses that are available to communities in adapting to climate change. In this diagram, most of the terminology is familiar to New Zealand communities and local authorities. Transformation is a term that is less familiar and possibly less relevant to New Zealand circumstances, in that it is described as *"the altering of fundamental attributes of a system (including values systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems)"*. Transformation is less likely to be needed in New Zealand's situation than in many parts of the world[14].

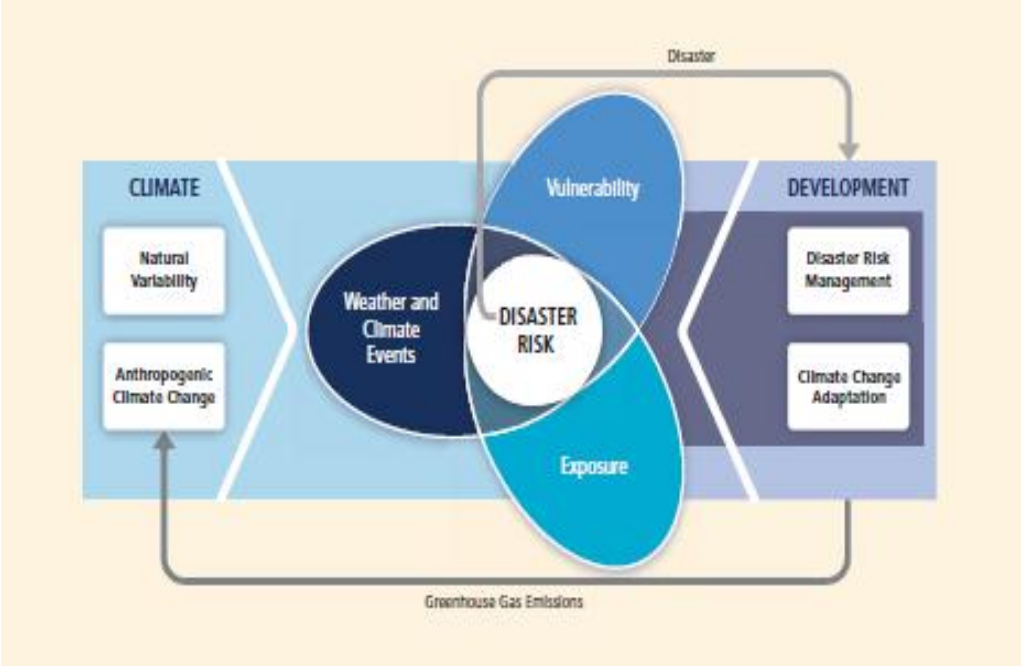

Figure 3.1: Relationships between Climate Change and People and Communities (Source: IPCC SREX Summary Report, November 2011).

[13] Ibid
[14] Transformation as a concept in New Zealand may be more applicable to reduction of greenhouse emissions in some sectors, including productive rural landuse and transport systems.

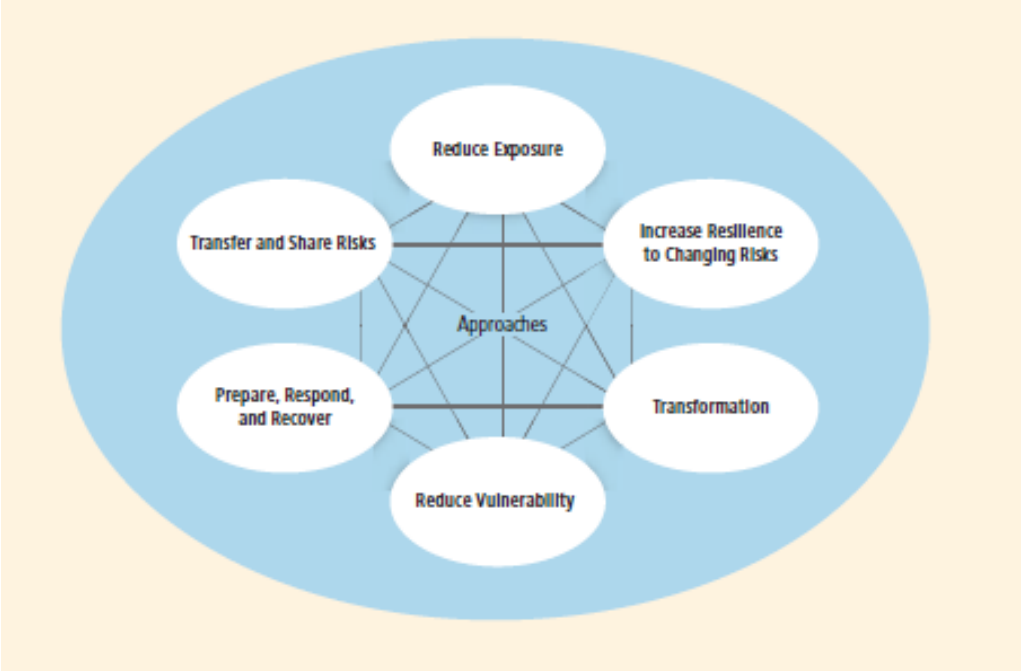

Figure 3.2: Adaptation and Disaster Risk Management Approaches for a Changing Climate (Source: IPCC SREX Summary Report, November 2011).

As noted, New Zealand's exposure to extremes is likely to be moderated by the country's location. Similarly, New Zealand's social, cultural and economic systems mean that the starting point for adaptability and resilience of urban communities is more advanced than in many parts of the world. For these principal reasons, 'managed adaptation' rather than transformation is more likely to be New Zealand's path.

Ideas for adaptation which have not been particularly emphasised in this Toolbox are those most likely to be associated with residual risk and extreme events; namely disaster management around the "three R's" of "readiness, response and recovery".

There is a substantial literature around emergency management, and growing experience in a range of urban circumstances. As with other aspects of climate change adaptation, communities and local authorities need to keep themselves informed about current and best practice. A state of readiness around early warning, good communication systems, means of ensuring physical safety, and protection of connectivity (services, access) and supply lines are key elements. Recovery poses different challenges.

It is also noted that a range of commentators has identified limits to adaptation responses. Some of these are emerging already, in the actions of insurance organisations increasing premiums or refusing to insure some properties. At present, these are primarily associated with flood risk in terms of climate-related matters, and a level of resistance to emergency preparedness (such as early warning systems) because

of ongoing cost and little obvious benefit. The challenge for communities is to keep options continuously under review, to make tough decisions when required, and to look for inventive opportunities – especially where there are co-benefits.

4. Adaptation as an Ongoing Process

A key message, noted throughout most climate change guidance material on adaptive responses, is the need to regularly review:

- information about the range of adaptation methods being used nationally and internationally; and
- information about the effectiveness of methods already in place.

Adaptation at the community level is an ongoing and conscious cyclic process of identifying risks, introducing partial or complete solutions/responses (sometimes involves innovation), evaluating effectiveness, learning through experience and reviewing.

Climate change involves processes which are not fully understood and risks which are likely to change over time. Furthermore, climate change is only one of numerous other physical, social, cultural and economic changes to affect communities over time. Maintaining community resilience in the face of climate change is a challenge which requires ongoing attention. This is particularly the case in urban communities where most of New Zealand's population live.

5. Sustainable Development and Mitigation

This Toolbox focuses on adaptation to climate change. However, climate change mitigation, through reduction in greenhouse gas emissions (and other methods such as carbon capture) is also a major element of endeavour towards sustainable development.

As noted earlier in this report, methods that facilitate mitigation frequently contribute to adaptation and vice versa.

The sustainable development framework that many local authorities and communities in New Zealand aspire to requires ongoing action in terms of both mitigation and adaptation.

6. References

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