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Abstract

Infrastructure that is being designed and built now is being designed on past climate, rather than the climate that infrastructure will experience during its expected life. Planning on the basis of a false assumption in this way presents a significant risk to governments, institutional investors, infrastructure sectors and individual organisations.

Climate change impacts on infrastructure will have a direct financial and reputational impact to corporations and government especially where public/private partnerships hand back a degraded asset to the state due to unexpected degradation and reduced life of an asset from changed climatic conditions.

Essentially each form of infrastructure (water, power, transport, buildings and communications) has key sensitivities to a change in particular climate variables such as extreme wind, solar radiation, extreme rainfall, heat waves, soil moisture. The direct exposure to climate change will of course depend on where they are located, the integrity/age of existing assets, the location of assets, the expected service life of assets and the dependence of assets on other supply services that may also be vulnerable such as water, power and access.

New investment for infrastructure will need to be 'climate ready' to meet future climate change design compliance. Organisations that are infrastructure intensive need to understand their existing direct exposure.

A range of climate change adaptation responses will be discussed using several Maunsell projects completed in recent years.

Introduction

Climate change presents a significant threat to infrastructure in many forms including buildings, coastal developments, water pipelines, transmission lines and road networks. The Australian Bureau of Statistics (ABS, 2003), values the Australia's homes, commercial buildings, ports and other physical assets at $1,957 billion. More than 80% of Australia's population resides within 50 km of the coast with increasing concentrations in regions already vulnerable to weather hazards (CSIRO, 2002).

To accommodate climate change nations, states, local government and corporations will need to consider the following:

- Vulnerability of infrastructure, assets and investment;
- Planning considerations; and
- New design and standards.

Infrastructure has been designed, built and maintained on the premise that future climate will be similar to that experienced in the past. Yet, increasing concentrations of atmospheric greenhouse gases are already influencing changes to climate conditions and indications are that it will continue to do so in the years and decades ahead. Planning on the basis of a false assumption in this way presents a significant risk to governments, institutional investors, infrastructure sectors and individual organisations.

The international scientific community is in general consensus that the global climate is changing due to the enhanced greenhouse effect. These changes will occur irrespective of efforts to reduce greenhouse gas emissions, although success in achieving mitigation will determine the magnitude and possibly the nature of the changes to which we will need to adapt. Clearly, it is paramount that nations continue efforts to reduce emissions of greenhouse gases, but sitting alongside such strategies should also be effective, efficient and well communicated adaptation plans.

Climate Change Adaptation

Although discussed theoretically since the 1980s, adaptation as an applied response to environmental change only gained practical traction following the Intergovernmental Panel on Climate Change's (IPCC) 3rd Assessment Report in 2001. Adaptation strategies aim to increase the resilience of human and natural systems to possible changes in climatic conditions, whilst taking account of the social dimensions of distributing losses. Such strategies should underpin the frameworks for managing future climate risk, offering the potential to reduce future economic, social, and environmental costs.

The Garnaut Climate Change Review in Australia indicates that, "Information about climate change and its likely impacts is the first requirement of good adaptation and mitigation policies. Flexible markets using the best available information are the second essential component for successful adaptation and mitigation policies." (Garnaut, 2008) The climate change adaptation of infrastructure related services and assets should be a priority for the sustainability of settlements and their prosperity through the challenges ahead.

Adaptation Drivers and Benefits

There are several drivers influencing the market to better understand and reduce risk to infrastructure associated with climate change impacts including:

- Credible information from Insurance companies on the 9 – fold increase in storm related events and payouts in the last 12 years in Australia; and
- Investment decisions that now factor climate change as part of investment risk. For example, climate change impact considerations for major port infrastructure investment in Australia;
- Reducing greenhouse gas emissions has traditionally been the focus globally around climate change. Recently the focus has began to move to adaptation to climate change impacts;
- Climate change impacts can be significantly mitigated by early planning, design and operation of infrastructure (For example refer to Association of British Insurers information box below);
- All levels of governments perceive the relationship between risk of infrastructure failure and loss of life with the possible future position of insurer of last resort; and
- The following benefits are identified by the implementation of adaptation strategies.

Short Term Benefits

Improved planning for:

- Residential, commercial and regional developments; and
- Water, power, transport, telecommunications facilities and structures.
- Investment decisions generating:
- Reduced risk of significant losses or liability; and
- Increased confidence in infrastructure projects due to climate change risk mitigation being integrated into project design.

Reputation and public confidence in management:

- Government;
- Industry; and
- Infrastructure assets.

Insurance coverage and reduced premiums for climate change assessed and risk controlled infrastructure projects.

Long Term Benefits

- Improved resilience of infrastructure to climate change impacts;
- Reduced asset maintenance costs;
- Reduced disruption to services and productivity;
- Better informed crisis management, enhancing public confidence and responses to crises; and

- Reduced risk to government, industry and/or community possessing no, or inadequate, insurance protection.

Adaptation Responses to Infrastructure Risks

The adaptation responses will vary depending upon the level of risk exposure. The adaptation response for any given location, region and infrastructure service will depend on the type and severity of the climate change impact to be avoided, mitigated or managed. The inherent climate and landscape characteristics of a location (i.e. flood or wind prone, coastal and marginal rainfall area) combined with potential climate changes need to inform infrastructure planning, investment, design and operation.

Maunsell have completed several significant climate change and infrastructure risk assessments and adaptation strategies in the past four years including the following: Climate Change Impacts to Infrastructure in Australia for the Garnaut Climate Change Review; Infrastructure and Climate Change Risk Assessment for Victoria; Climate Change and NSW State Roads; Barwon Heads Bridge Development Climate Change Assessment; City of Melbourne Climate Change Risk Assessment and Climate Change Adaptation Strategy; Whitehorse City Council Climate Change Risk Assessment; Gerringong to Bomaderry Route Selection Climate Change Assessment; Melbourne Water Climate Change Risk Prioritisation Strategy; CitiPower/Powercor and ETSA's Environment and Climate Change Strategy; Cocos and Christmas Islands Climate Change Risk Assessment; and Sydney Water Climate Change Risk Assessment.

From Maunsell's experience in climate change risk and adaptation several adaptation responses are identified and outlined as follows:

Risk Assessment and Adaptation Planning of Assets, Organisations and Government Jurisdictions

From Maunsell's experience large organisations will benefit from a strategically aligned climate change risk assessment using ISO 4369 Risk Management processes to identify and prioritise a range of asset and operational risks. These identified and analysed risks should primarily be managed through existing risk management frameworks within the organisation. Where significant and progressive change is required to address risks and opportunities for business development then an adaptation plan is required.

Government jurisdictions (local, state and national) and large corporations should have a whole of jurisdiction climate change adaptation plan. While all jurisdictions of government share some responsibility for various aspects of public infrastructure, municipalities carry the greatest responsibility for adapting infrastructure to climate change (Mehdi, 2006)

The assessment of climate change impacts to infrastructure has been conducted by Canada, US, UK, Australia and New Zealand. To date only Canada and Australia has researched the potential costs and impacts of climate change on infrastructure. Figure 1 shows the likely significance of the cost of adapting to climate change in Canada for a sample of major infrastructure.

Figure 1 Estimated costs for adapting selected infrastructure in Canada[1]

Adaptation	Estimated cost
Constructing all-weather roads (not on permafrost)	$85,000 per km plus $65,000–$150,000 per bridge
Constructing all-weather roads (on permafrost)	$500,000 per km
Replacing coastal bridges to cope with sea level rise	$600,000 per bridge
Expanding wastewater treatment capacity (Halifax)	$6.5 billion

It should be noted that the Canadian experience is based on 'assessing economic impacts of climate change involves estimating the value of direct and indirect market and non-market costs of implementing adaptation options and the benefits gained as a result of the adaptation'(Government of Canada, 2004, p25).

The Association of British Insurers report 'Financial Risks of Climate Change' looks at the implications of climate change on the insurance industry. The report estimates that without action to restrict climate change, the cost of insured damage in a severe US hurricane season could rise by three-quarters, and that the costs of flooding in Europe could increase the annual flood bill by up to £82 billion. However, by addressing climate change now, the ABI states that insurers' increased capital requirements for hurricanes, typhoons and windstorms could be reduced by more than £33 billion, with strong, well-enforced building codes to prevent and reduce windstorm damage, while in the UK, effective flood management could save 80% of the costs of flood damage (ABI, 2005).

Organisations will need to have a climate change plan to maintain insurance cover, or maximise the level of insurance undercover in the future. It is an obligation, particularly for the corporate and government sectors to demonstrate that it has taken appropriate (reasonable) steps to avoid an insurable loss. Therefore, insurers are likely to demand infrastructure owners to demonstrate how potential threats of climate change will be mitigated to reduce potential loss exposure.

Land use planning is another important adaptation measure for coastal communities, flood zones, and areas facing potential water shortages. For example:

- Zoning of residential, commercial and recreational areas would need to be adapted to meet changes in coastal, flood plain and rainfall conditions;
- Master and structure planning, development control plans and local environment plans will need to incorporate a strategic approach to climate change impacts in the local council area;
- Planning of essential services and community response for their area to build resilience in extreme weather events;

[1] based on a 5% increase in mean temperature and a 10% increase in mean precipitation over the present century. All dollars based on 2001 value in Canadian dollars.

- Essential services planning will need to adapt to manage changed resource demand pressures. Two areas of focus could be:
- To capture and store stormwater locally to supply the expected shortfall in rainfall and traditional reservoir supplies; and
- To create local distributed renewable or low carbon power generation to reduce the vulnerability of the electricity system during heatwave and extreme storm events.
- The upgrading of the energy efficiency of existing building stock as well as new buildings is required to reduce the demand pressures on energy infrastructure and supply during heatwaves.

Due to changes in climate, existing technology may not be able to deliver the services, in the future, that the community expects. For example, engineering solutions may involve technologies focused on localised stormwater collection systems and local reuse in preference to dam catchment and storage. Another example would be the types of roofing technology used for new residential housing to withstand greater wind velocities and storm related damage like water intrusion into eaves. Some technologies would be required to adapt existing buildings to an increased standard of weather proofing.

Innovation of complex systems like water, power and transport systems that compose of integrated human and infrastructure elements require a collaboration of vastly different ideas and expertise to generate new or improved system solutions that not only address the current perceived problem but identify and overcome an array of minor problems that together make up the perceived problem.

Innovation of systems will be necessary when climate change coupled with population growth increases resource demand pressures. For example, in managing severe water shortages within settlements and throughout agricultural regions which are dependent on irrigation. In some circumstances where the risk to infrastructure is extreme, the retreat of services, infrastructure assets and development may be required. For example, the impact of sea level rise combined with the increased frequency and intensity storm surge events will require, at some locations, a retreat of buildings, facilities, water, energy, transport (ports) and telecommunications infrastructure.

Guidelines for Local Use of Design Standards, Materials Selection and Maintenance

The guidelines for design standards for infrastructure need to be adjusted to allow for changes in the range of expected extreme events as well as climate change accelerated degradation of certain materials and structures. For example with floods, a 25% increase in 30 min precipitation can be the equivalent of a flood return period reduced from 100 years to 17 years (Coleman, 2003)

This would also mean that the new flood levels for the 100 year flood event would be substantially greater/higher in magnitude. In this instance, design standards and requirements for flood prone infrastructure and storm water management would need to be applied to a greater area and range of infrastructure assets. Determining design thresholds and expectations for infrastructure service will prioritise adaptation responses.

The maintenance regime of assets over time will need to adapt to the acceleration in the degradation of materials and structures. For example, preventative maintenance regimes of buildings, roads, bridges and tunnels to maintain structure integrity and avoid significant affects by climate change impacts on steel, asphalt, concrete joints, foundations, protective cladding, coatings and sealants.

A change in the selection of materials for infrastructure components that will be exposed to changed conditions will be an important initial step for most forms of infrastructure. The selection should be based on the desired life expectancy of the infrastructure and maintenance regime.

For example, road surfaces in some areas will be exposed to increased temperatures and solar radiation leading to accelerated degradation of the asphalt surface. Allowing for this increase in temperature and solar radiation in the design guidelines for a region will require the materials mix resembling the mix used for regions where temperature and radiation levels are relatively higher.

Similarly, infrastructure in close proximity to the coast such as wharfs, bridges and sea walls will need to incorporate changes in sea surface temperature, spray zones and corrosion resistance levels of materials to compensate for higher temperatures and sea level rise. Material degradation in infrastructure may make the structure more prone to being impacted by extreme storm events.

Conclusion

Climate change impacts will affect water, building, power, transport and telecommunication infrastructure assets.

Decision makers in government and private sector organisations have the opportunity to identify and mitigate climate change risks to infrastructure assets, which will significantly reduce the financial and social costs of the future.

Organisations that own and manage infrastructure assets need to understand their direct exposure to climate change impacts. Organisations that are dependent on infrastructure services for business continuity need to better understand their indirect exposure to climate change impacts.

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