AGIC Guideline for Climate Change Adaptation

AGIC

Australian Green Infrastructure Council

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AGIC Sustainability Rating Scheme
Climate Change Adaptation
Guideline for Infrastructure

Purpose

This guideline has been developed to inform industry on climate change risks and opportunities presented for new infrastructure projects and existing assets. It provides a roadmap for developing appropriate adaptation measures.

The benefits of addressing climate change risks and opportunities include satisfying approval requirements, reducing risk and incorporating 'win-win' features. These broader benefits include 'no regrets' actions. These are actions that make sense and add value whether or not the climate change risk eventuates.

Adaptation measures to address climate change vulnerability can include both '*structural' and 'non-structural'* measures. Structural measures are physical changes to the infrastructure to achieve or facilitate adaptation and non-structural are other measures such as changes to contracts or implementing an emergency management plan.

This guideline also provides:

- An explanation about climate change adaptation assessment to align with the AGIC Rating Scheme; and
- A range of adaptation measures using industry examples.

The challenge and vision for climate resilient infrastructure is highlighted in the box on the right.

The Challenge

The variability of future climate conditions internationally and across Australia poses challenges to designing and operating infrastructure assets.

The Vision

Imagine infrastructure:

1. with the capacity to be more resilient against intense, frequent storm events, extended droughts, increased temperatures, variable precipitation patterns and sea level rise inundation.
2. providing more reliable regional transport networks to prepare for and recover from natural disasters.
3. protecting coastal urban areas from rising sea levels and storm surges.
4. that does not need regular retrofitting and is not based on short term solutions, thereby future proofing infrastructure and economies for future generations.

Introduction

There is consensus amongst climate scientists that human activities are a significant contributor to observed global warming. The world is already committed to some degree of unavoidable global climate change. Natural cycles have reportedly skewed past a point of equilibrium and the consequences of these changes on infrastructure are imminent or already occurring[1].

Climate change has significant potential to disrupt or damage existing and future infrastructure. Rising sea levels and storm surge threaten to weaken coastal infrastructure and impact freshwater supplies. Increased intensity of storm, wind and flood events could cause damage to buildings and regional transport networks.

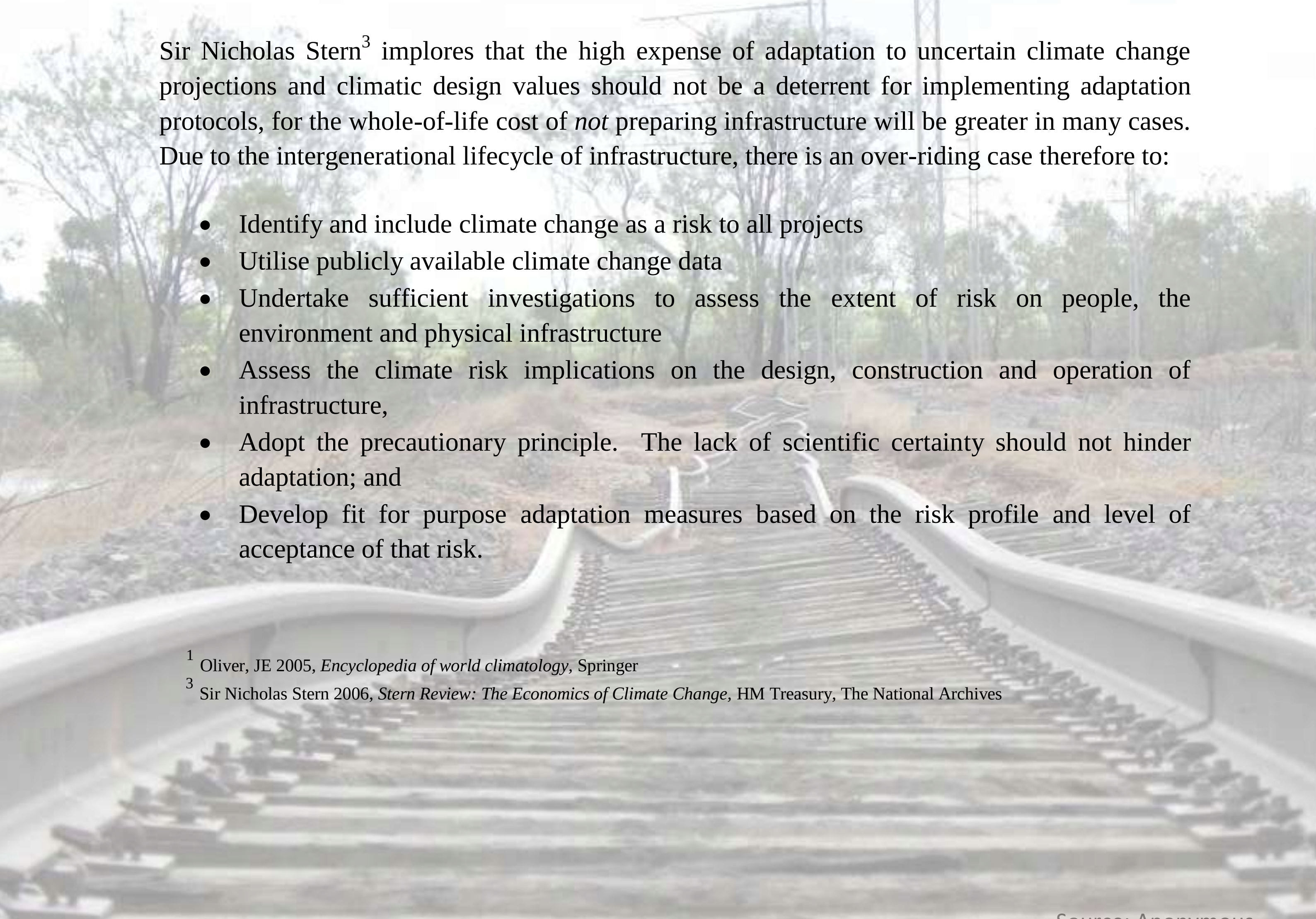
Infrastructure plays an important role in the form of our urban environments and growth of economies. Infrastructure has been designed, built and operated on the basis of historical weather records and assumes that the future climate would be the same as in the past. This assumption has to change.

Climate change adaptation means historical weather records are no longer a reliable guide to future climate and it is important for industry to update policies and assessment methods as new climate information becomes available.

Sir Nicholas Stern[3] implores that the high expense of adaptation to uncertain climate change projections and climatic design values should not be a deterrent for implementing adaptation protocols, for the whole-of-life cost of *not* preparing infrastructure will be greater in many cases. Due to the intergenerational lifecycle of infrastructure, there is an over-riding case therefore to:

- Identify and include climate change as a risk to all projects
- Utilise publicly available climate change data
- Undertake sufficient investigations to assess the extent of risk on people, the environment and physical infrastructure
- Assess the climate risk implications on the design, construction and operation of infrastructure,
- Adopt the precautionary principle. The lack of scientific certainty should not hinder adaptation; and
- Develop fit for purpose adaptation measures based on the risk profile and level of acceptance of that risk.

[1] Oliver, JE 2005, *Encyclopedia of world climatology,* Springer
[3] Sir Nicholas Stern 2006, *Stern Review: The Economics of Climate Change,* HM Treasury, The National Archives


Source: Anonymous

Climate Change Observations and Projections

Climate change impacts can be understood through many sources (refer Box 1), a key one being the United Nations' Framework Convention on Climate Change (UNFCCC). This has set the foundation framework for climate change data collation, forecasting and adaptation research[1].

The impact of climate change is highly dependent on the location as sensitivity to and exposure of climatic conditions varies geographically. Extended collaborative research has produced global climate change projections, the most recent global assessment being the Fourth Assessment Report (AR4) compiled by the Intergovernmental Panel on Climate Change[2] (IPCC).

It must be noted that climate change modelling is an area of continual improvement and therefore updated as new findings are released. At the time of this Guideline's publication, the Fifth Assessment Report, (AR5) is underway.

Box 1: Technical Reports

i. United Nations' Framework Convention on Climate Change
http://unfccc.int/

ii. Intergovernmental Panel on Climate Change (2007)
http://www.ipcc.ch/ipccreports/ar4-wg1.htm

iii. Australian Online Coastal Information
http://www.ozcoasts.org.au/climate/sd_visual.jsp

iv. Department of Climate Change
http://www.climatechange.gov.au/~/media/publications/coastline/cc-risks-full-report.pdf

v. Climate Change in Australia
http://www.climatechangeinaustralia.gov.au/technical_report.php

Interpretation of the IPCC's AR4 report and region specific research for Australian terrestrial environments has been modelled by national organisations. The CSIRO report on projected climate change outcomes for Australian environments covers a comprehensive scope of the physical changes that will impact infrastructure assets[5].

Box 2: Climate change risks and impacts

Rise in sea level:

- Saline intrusion into coastal freshwater aquifers
- Coastal land inundation
- Water table elevation resulting in subsurface structure flooding/corrosion and foundation soil saturation
- Wave damage and accelerated corrosion caused to coastal infrastructure and beaches
- Change in tidal variations

Increased temperature:

- Amplified risk of bushfire days
- Prolonged heat wave events adding stress to rail, road and energy distribution networks

Rainfall Variability:

- Changes in catchment runoff and water availability
- Increased frequency and intensity of droughts and storm events
- Increase to inland and southern areas exposed to cyclones
- Increased height and land penetration of storm surges
- Changes in local and regional flooding risks
- Changes in landslide and erosion risks

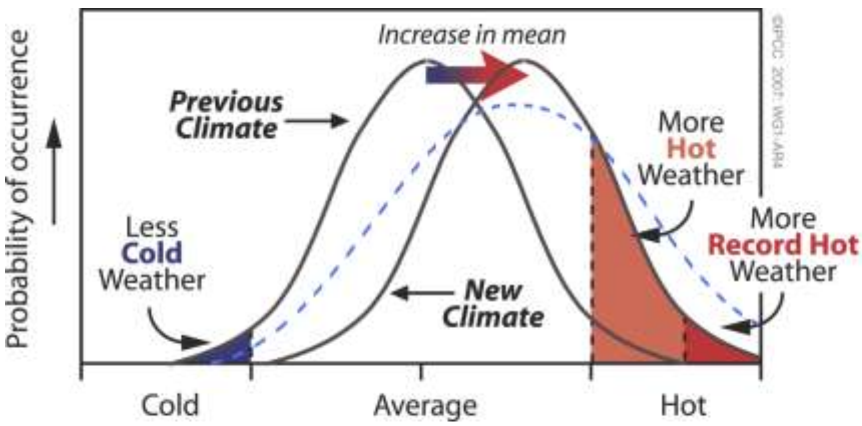
Analysis of Australia's historical climate data exhibits evidence of inland and coastal temperature increases of 0.4 to 0.9°C respectively since 1950 records[4]. The CSIRO and Bureau of Meteorology state that by 2030, further warming of 0.7 to 1.2°C on average based from 1990's data, will significantly increase the number of hot days and that an average maximum increase of up to 5°C could be expected by 2070[5].

Figure 1 has been adapted from the IPCC's 2007 AR4 report and illustrates the generic mean temperature distribution for historic world climates. Although a broad prediction, this depicts an increase in the probability of warmer average day temperatures and fewer cold nights.

The increase in mean temperatures is likely to change wind patterns and rainfall frequency and storm distribution across Australia. Precipitation is projected to decrease more in the southwest of the continent and possibly increase in the north with a -30% to +20% range by 2070 (5).

Box 2 provides a range potential impacts that relate to changes in specific climatic conditions.

Figure 1: Increase of annual daily mean and extreme temperatures.



[5] CSIRO, 2007. *Climate Change in Australia: Technical report 2007*

[6] Australian Government – Department of Climate Change 2009, Climate Change Risk to Australia's Coast: A First Pass National Assessment.

Government and Industry State of Play

Several infrastructure related governments and private sector organizations have developed frameworks and initiatives to assess climate change risks, opportunities, adaptation measures and programs[7]. A small selection is described here and whilst these frameworks and measures vary from agency to agency, the direction is consistent.

The National Climate Change Adaptation Framework[8] identified "settlements and infrastructure" as one of six key sectors to fill critical knowledge gaps needed by decision makers. The National Climate Change Adaptation Research Plan[9] was developed to address key issues and set a national precedence for all of industry to benchmark.

There are varying requirements in each state to demonstrate climate resilience infrastructure projects and operations.

In Queensland, proposed new state roads and major road upgrades require a Climate Change Impact Statement (CCIS) for all budget, policy and proposal submissions to the Queensland Cabinet[10]. The Statement must include an assessment of climate change risks and adaptation measures. Furthermore, all projects requiring an Environmental Impact Statement must accommodate adaptation responses[10]. The Queensland Climate Change Center of Excellence[13] introduced the ClimateSmart Adaptation 2007/12 Action Plan[14] which outlines actions that strengthen the adaptive capacity and resilience to climate change across all priority sectors of Queensland's infrastructural assets. The SEQ Regional Plan also includes adaptation requirements.

In Victoria, the City of Melbourne requires consideration of climate change implications in the approval process of major developments. Within the Victorian Planning Provisions it is also stipulated that local planning authorities design for no less than a 0.8m sea level rise by 2100 for new coastal infrastructure projects[15].

In Tasmania, the Tasmanian Government [16] also requires major development proposals to include a Climate Change Impact Statement and has issued guidelines and a template to assist.

In NSW, Sydney Water is pursuing a multi-faceted approach to build its climate change adaptation capacity having already assessed climate change risks. This includes promoting greater awareness of climate change amongst technical staff, analysing interdependencies with other utility sectors, geospatial mapping to identify critical vulnerabilities and assets exposed to climate change risks and quantifying the costs and benefits of adaptation measures.

[7] Australian Climate Change Adaptation Research Network: Settlements and Infrastructure 2010, *Position paper: framing a national climate change adaptation policy for the built environment*, http://www.nccarf.edu.au/

[8] Council of Australian Governments 2007, *National Climate Change Adaptation Framework*, http://www.coag.gov.au/coag_meeting_outcomes/2007-04-13/docs/national_climate_change_adaption_framework.pdf

[9] Australian Climate Change Adaptation Research Facility 2010, *Australian Climate Change Adaptation Research Plan: Settlements and Infrastructure*, http://www.nccarf.edu.au/sites/default/files/NCCARF%20Settlement%20Book%20FINAL.pdf

[10] Queensland Government – Department of Transport and Main Roads 2009, *Road Traffic Air Quality Management Manual: Appendix C - Road Traffic Air Quality Management Manual Climate Change Impact Statement and Climate Change Impact Assessment*

Climate Impacts on Infrastructure Sectors - Examples

The following is an initial qualitative assessment of climate change risk to equip industry stakeholders with a platform for comparison when applying the AGIC Rating Scheme. The examples highlight climate change effects to infrastructure.

Example 1: Transport and built infrastructure

Threat:

Climate change has the potential to significantly impact on the built environment and could disrupt everyday transport operations to an unprecedented degree. The majority of infrastructure assets are located within 50km of the coast where over 85% of Australia's population lives.

Climate change alters the variability of precipitation and is likely to increase the intensity of extreme weather events. Inundation of coastal land would be exacerbated by high water tables, and flash flooding especially during periods of La Niña Southern Oscillation cycles[18]. Extreme storm events, winds and tidal surges will increase exposure of infrastructure to damage.

[13] Queensland Government – Queensland Climate Change Centre of Excellence http://www.climatechange.qld.gov.au/whatsbeingdone/queensland/centreofexcellence/index.html

[14] Queensland Government – Department of Natural Resources and Water 2007, *ClimateSmart Adaptation 2007/12* http://www.climatechange.qld.gov.au/pdf/climatesmart_plan.pdf

[15] Victorian Government – Department of Planning and Community Development 2010, *State Planning Policy Framework: 13 Environmental Risks*

[16] Tasmanian Government – Department of Premier and Cabinet 2008, *Climate Change Impact Statement Guidelines*, Templates

[17] A, Stokes 2009, National Sea Change Taskforce, *Demographic Change in Coastal Australia*

Climate change hazards:

- As sea levels rise, salt intrusion into freshwater aquifers along coastal regions will pollute accessible reserves, potentially reducing water availability for infrastructure projects. The inherent rise in water tables can corrode and alter the structural dynamics of subsurface infrastructure such as sewerage networks, underground basements and petrol storage tanks. Load bearing concrete structures subject to salt water contact can be structurally jeopardised as chloride ions penetrate porous cement and react with oxygen to corrode steel reinforcements[19].
- Water table elevation threatens the integrity of building foundations built on permeable soils that can saturate, decay or rapidly sink. Increasing fatigue on affected areas can result in structural failure during high tensile stress brought by intense storm events.
- Increased acidification and salinity of oceans caused by climate change can accelerate deterioration of materials and concrete structures in the marine environment[4]. The speed is exasperated by the effect of storms and wind causing wave events.
- Raised sea levels could result in backup/blockages of drainage and sewerage outlets increasing the risk of flooding and release of pollutant biohazards. The risk is amplified as current storm water drainage and sewerage pipes may not be adequately designed to cope with future extreme rainfall events and surges[20].
- Beach erosion due to higher sea levels, intense storms and floods will result in coastal infrastructure damage and losses.
- The life expectancy of affected assets may decline or the frequency for retrofitting, replacing and maintaining may increase. For example the longevity of building materials may be reduced such as protective cladding, paints, glass, adhesives and petrochemical based compounds.
- High temperatures and ultra-violet radiation hastens the deterioration of road infrastructure and can buckle rail lines, impeding transport of goods including mineral resources
- Temperature rise associated with climate change, is likely to intensify the "urban heat island" effect, particularly with increased urban density, more paved surfaces and vegetation loss.
- Soil subsidence, movement and cracking as a consequence of unseasonal wetting and drying cycles, poses risks to built and natural environments.
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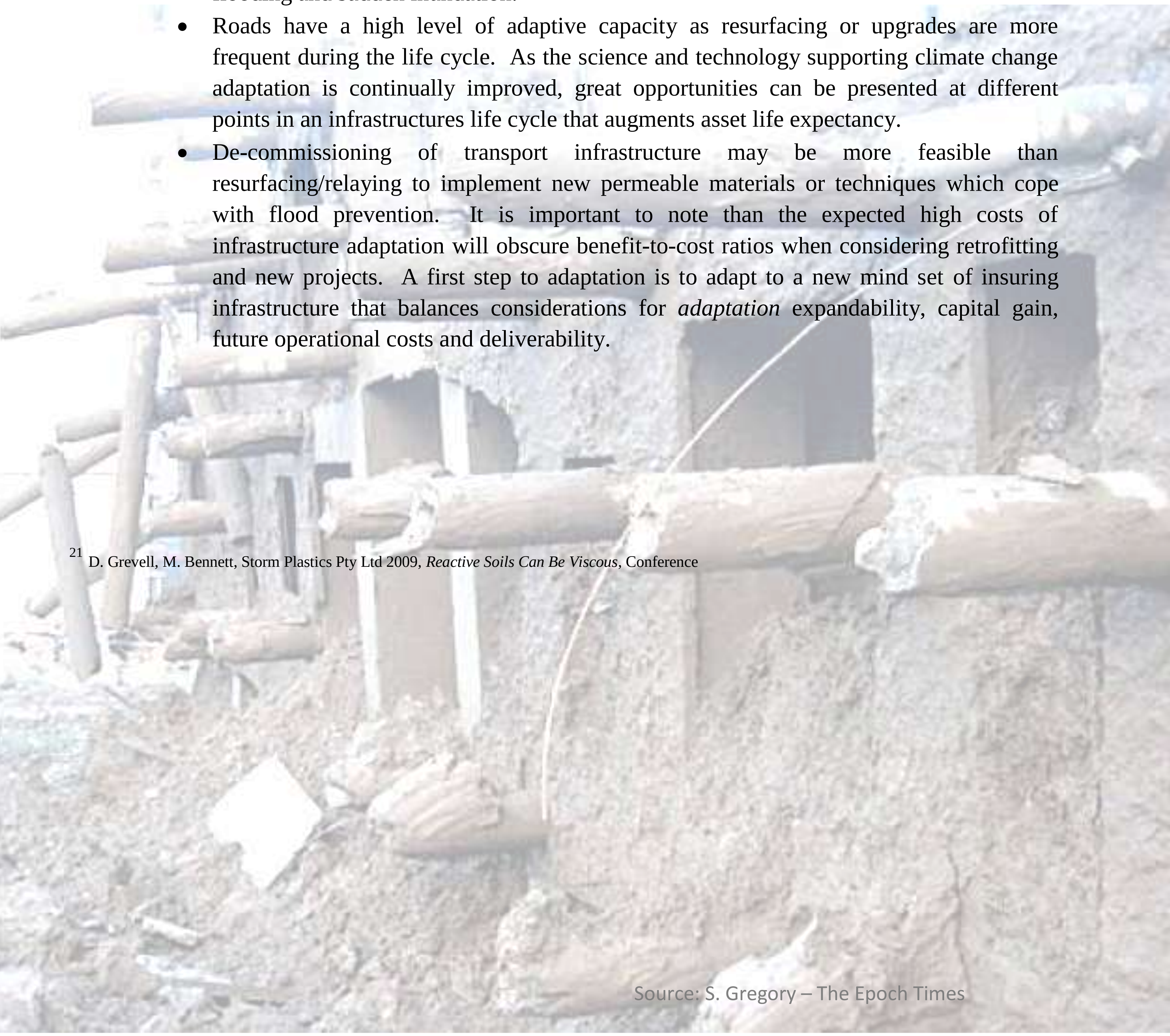
Source: Pacific Islands Regional Integrated Science and Assessment Climate Program (Pacific RISA)

[19] Portland Cement Association 2011, Concrete Technology: Corrosion of Embedded Metals

[20] Australian Government – Department of Climate Change and Energy Efficiency 2009, *Climate Change Risks to Coastal Infrastructure, Industry and Essential Services*, Publications

Adaptation responses:

- In planning stages of a project, consider the potential impacts of a changing climate generating exacerbated flood, storm surge, inundation, heat, extreme storm and weather events. Use climate change projections to analyse the impact on people, the environment and the physical infrastructure.
- Build in adaptive capacity in infrastructure design. Incorporate recent policy or best industry guidelines that relate to climate resilient design. These may include information on sea level rise and heat impacts.
- During de-commissioning phases, containment of hazards presents a new challenge in response to changing intensity of extreme weather. New measures may be required that better respond and adapt to the greater scale of extreme weather events, such as flash flooding and sudden inundation.
- Roads have a high level of adaptive capacity as resurfacing or upgrades are more frequent during the life cycle. As the science and technology supporting climate change adaptation is continually improved, great opportunities can be presented at different points in an infrastructures life cycle that augments asset life expectancy.
- De-commissioning of transport infrastructure may be more feasible than resurfacing/relaying to implement new permeable materials or techniques which cope with flood prevention. It is important to note than the expected high costs of infrastructure adaptation will obscure benefit-to-cost ratios when considering retrofitting and new projects. A first step to adaptation is to adapt to a new mind set of insuring infrastructure that balances considerations for *adaptation* expandability, capital gain, future operational costs and deliverability.



[21] D. Grevell, M. Bennett, Storm Plastics Pty Ltd 2009, *Reactive Soils Can Be Viscous*, Conference

Source: S. Gregory – The Epoch Times

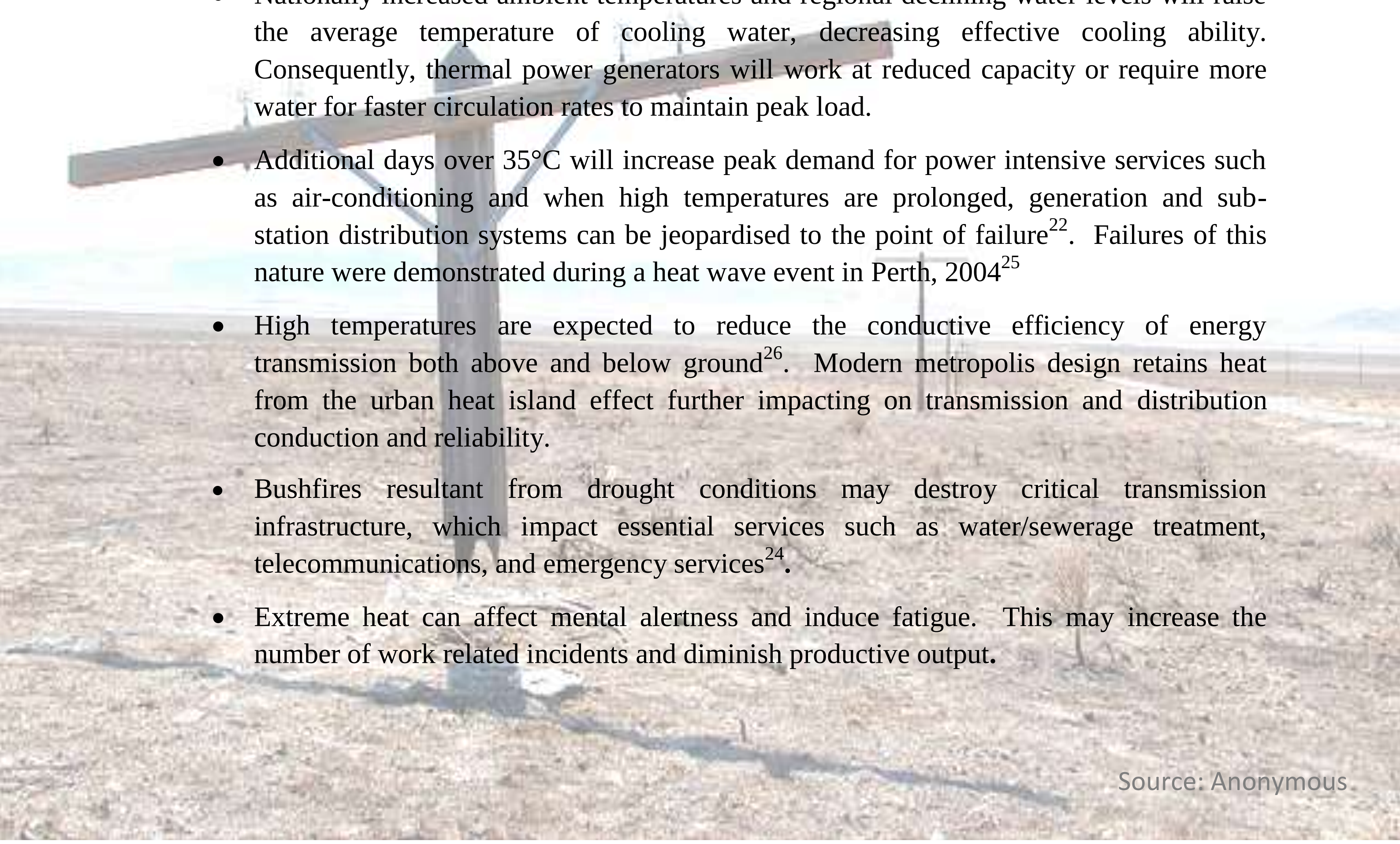
Example 2: Energy generation and transmission

Threat:

Australia's civilisations and the systems that sustain them are dependent on electricity for the operation of everyday living. All electric devices emit heat and most need additional cooling reliant on ambient air temperature differentials. The major threat to electrical systems is coping with additional heat stress and more frequent overheating which has the cascading potential to disrupt essential services. Higher temperatures can intensify storm cells causing disruptions and damage to energy networks. Increased frequency of drought conditions will reduce water security especially for thermal power generation.

Climate change hazards:

- Thermal power installations are generally close to a source of fuel, cooling water and settlement. Severe, frequent droughts as a consequence of changing rainfall patterns will put pressure on water supply as demand increases. Due to greater evaporation and variable precipitation patterns, some of the flows in tributaries and waterways may be reduced, or at worst stop flowing making the use of water for cooling less reliable.
- Nationally increased ambient temperatures and regional declining water levels will raise the average temperature of cooling water, decreasing effective cooling ability. Consequently, thermal power generators will work at reduced capacity or require more water for faster circulation rates to maintain peak load.
- Additional days over 35°C will increase peak demand for power intensive services such as air-conditioning and when high temperatures are prolonged, generation and sub-station distribution systems can be jeopardised to the point of failure[22]. Failures of this nature were demonstrated during a heat wave event in Perth, 2004[25]
- High temperatures are expected to reduce the conductive efficiency of energy transmission both above and below ground[26]. Modern metropolis design retains heat from the urban heat island effect further impacting on transmission and distribution conduction and reliability.
- Bushfires resultant from drought conditions may destroy critical transmission infrastructure, which impact essential services such as water/sewerage treatment, telecommunications, and emergency services[24].
- Extreme heat can affect mental alertness and induce fatigue. This may increase the number of work related incidents and diminish productive output.



Source: Anonymous

[25] Australian Government – Bureau of Meteorology 2011, *Heatwaves*

Example 3: Water management

Threat:

Changes to rainfall patterns and increased intensity of storm events will impact water management assets such as water infrastructure designed to capture, store and distribute water. Overall Australia will become a drier continent[5]. All new water infrastructure needs to consider climate risk.

Climate change hazards:

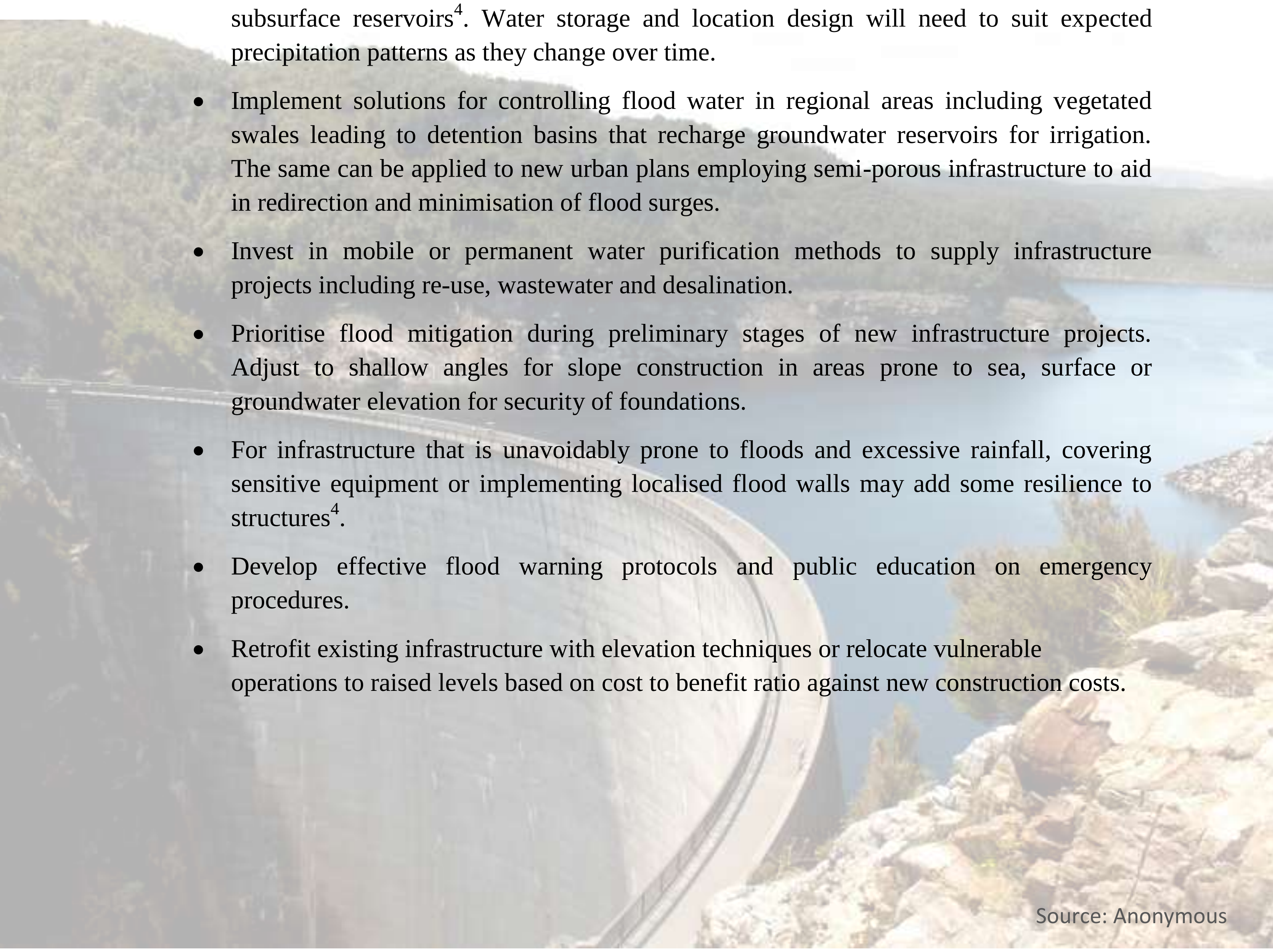
- In areas affected by decreasing annual rainfall coupled with higher evaporation rates the infiltration and runoff rates will decrease impacting inflows into water storages.
- Storm water infrastructure such as pipelines and pumping stations designed for historical 1-in-100 year rain events will not cope with future volumes and may increase damage to urban public assets.
- Dam integrity and capacity will be challenged by soil erosion and increased siltation resulting from flood waters[27].
- Extreme floods increase the flow of nutrients into reservoirs leading to algal blooms, also effecting potable water quality making processing more difficult and expensive.

[24] Intergovernmental Panel on Climate Change (IPCC), 2007 "*The Physical Science Basis*" Fourth Assessment Report: Working Group I

Source: Marc Kuliszer

Adaptations and opportunities:

- Investigation of adaptation and flexibility during the design and planning for long lived assets. Plan construction locations above historic flood levels.
- Other considerations include physical controls to raise assets above anticipated flood levels such as levee banks, raised earthwork platforms and raising floor levels.
- Consider low cost strategies for potable water storage. Structural adaptations may include installation of water tanks for water re-use, therefore reducing dependence and cost during operational phases. Non-structural adaptations may include reducing demand by means of education or financial incentives/deterrents. A high cost strategy is to increase storage capacity or incorporate alternative sources such as desalination and subsurface reservoirs[4]. Water storage and location design will need to suit expected precipitation patterns as they change over time.
- Implement solutions for controlling flood water in regional areas including vegetated swales leading to detention basins that recharge groundwater reservoirs for irrigation. The same can be applied to new urban plans employing semi-porous infrastructure to aid in redirection and minimisation of flood surges.
- Invest in mobile or permanent water purification methods to supply infrastructure projects including re-use, wastewater and desalination.
- Prioritise flood mitigation during preliminary stages of new infrastructure projects. Adjust to shallow angles for slope construction in areas prone to sea, surface or groundwater elevation for security of foundations.
- For infrastructure that is unavoidably prone to floods and excessive rainfall, covering sensitive equipment or implementing localised flood walls may add some resilience to structures[4].
- Develop effective flood warning protocols and public education on emergency procedures.
- Retrofit existing infrastructure with elevation techniques or relocate vulnerable operations to raised levels based on cost to benefit ratio against new construction costs.



Source: Anonymous

[24] Intergovernmental Panel on Climate Change (IPCC), 2007 "*The Physical Science Basis*" Fourth Assessment Report: Working Group I

[25] Australian Government – Bureau of Meteorology 2011, *Heatwaves*

[26] PMSEIC Independent Working Group. 2007. *Climate change in Australia: Regional impacts and adaptation – Managing the risk for Australia*, Report

[27] Water United Kingdom 2008, *Adaptation to climate change: How the water industry is adapting to climate change,* Briefing

Six Criteria for addressing Climate Change Adaptation

Climate change risks and opportunities can be addressed through the application of the six criteria listed below. The associated "benchmarks" to be used in the forthcoming AGIC rating scheme describe the performance levels for each criteria reflecting business-as-usual to leading practice. The degree to which these benchmarks apply in the rating scheme are summarized in Table 1 and will be provided when the Tool is formally launched. Examples have also been provided in the following sections.

(1) Commitment

This criterion relates to the commitment of the key project or asset stakeholder(s) in recognising climate change risks and opportunities in all aspects of a project and taking the necessary actions to avoid or manage the risks.

(2) Capability

This criterion relates to the technical capability and experience of those responsible for managing climate change risks to the project or asset.

(3) Climate Change Projections

This criterion relates to the credibility and appropriateness of the climate change projections used to assess project specific climate change risks.

(4) Climate Change Risks Assessed

This criterion relates to the range of climate change risks assessed – how narrow or broad - and the appropriateness of the risk assessment methodology used.

(5) Adaptation Options Assessed

This criterion relates to the quality of the assessment of adaptation options identified. It includes consideration of the extent and depth options identified and explored, documentation of the decisions made, the timing of implementation, flexibility and innovation.

(6) Adaptation Measures Designed or Implemented

This criterion relates to the effectiveness of the adaptation measures designed or implemented to address the climate change risks. The measures include assessing the extent of priority risks treated; the integration, systemization and timing of adaptation measures as well as the adaptive capacity of project or asset operators.

Considerations for Assessing Climate Change Risks

Effective climate change risk assessment should follow a systematic approach. AGIC advocates transparency of risk decisions and endorse the use of ISO 31000 Risk Management Standard.

A series of questions shown in Box 3 are intended to prompt risk identification and knowledge gaps across all stages of a project, from concept to decommissioning.

Further Examples of Risks Associated with Climate Change

- Flood Liability. Much of Australian infrastructure is built on flood plains and as such, approval for insurance of assets will become increasingly challenging or unobtainable without proof of adaptive capacity[29].
- Infrastructure damage and loss of services to community.
- Communities isolated by floodwater. Water dependant infrastructure and communities are vulnerable to extreme variation in precipitation as scarcity or flooding.
- Contamination of sites. During flood events, landfills or sites harbouring hazardous materials may become inundated resulting in releases of contaminants[4].
- Construction delays. Floods can destroy and disrupt construction, mining or existing infrastructure assets.

Box 3: Prompts for Identification of Risks & Knowledge Gaps

- To what extent can historical and projected climatic trends be best applied to assess the vulnerability of existing and future infrastructure under different climate change scenarios?
- What data is required and is available to assess the risk such as knowledge of ecology, geology, hydrogeology, architecture, seismology, material/ soil/fluid mechanics, communities and their interdependencies?
- How will implementation of climate change adaptation effect existing planning methodology, principles and delivery? How will adapted design differ based on local conditions, resource availability, magnitude and lifecycle?
- How will extreme climate events impede construction methods and materials and what operational strategies can be implemented to reduce hazard associated risks?
- How will increased periods of warmer weather impact on labour productivity such as fatigue and higher accident rates?

Source: Developing 8 – Organization for Economic

Considerations for Assessing Adaptation Measures

It is recommended that the use of adaptive management be employed in responding to the impacts of climate change to infrastructure. Adaptive management can minimise the financial and structural risks to infrastructure by applying flexibility in design to build climate resilience over time. In some instances, full up-front investment in an adaptation measure is not required where partial investment up-front is adequate to reserve the ability to respond later to projected impacts that are not expected to take effect until later in the century such as reserving land for sea wall protection to be implemented later.

The adaptation measures may be of a *structural* nature such as analysing infrastructure failures, regular infrastructure maintenance and retrofitting of existing assets. Actions may also be n*on-structural* measures and include changes to contracts, planning instruments and policy, implementing disaster management planning[30].

The questions in Box 4 may assist in identifying project-specific knowledge gaps.

Box 4: Identifying Project – Specific Knowledge Gaps

- What is the historical adaptive capacity of infrastructure and emergency planning? How does this change, if at all, as a result of climate change? What are the project implications of these changes?
- What are the specific requirements or policy expectations at the Federal, State and Local government level?
- How can resilience be applied in the design phase?
- What time frame should the average recurrence interval be adjusted to suit new infrastructure standards?
- Can adaptive methodologies to infrastructure assets present beneficial economic, social or environmental opportunities?

Further Examples of climate change adaptation options in Design

- Increase capacity of drainage/sewerage networks
- Investigate material alternatives for foundations and review current pile specifications
- Accommodate new Accelerated Erosion Index (AEI) and Average Recurrence Interval (ARI) indexes of rainfall and runoff, currently being revised by Engineers Australia[4].
- Avoid surface construction on flood prone zones. Note: Urban growth may impact on flood storage capacity
- Introduce low-absorbent, heat reducing materials and design to minimise heat infiltration.
- Workforce fatigue and injury. Combat worksite construction delays by prefabricating (where possible) in ideal environments and providing onsite ventilation or shading. Rescheduling construction times, such as night periods, to avoid heat stress on labour force.

[30] H.·Auld and D. MacIver. Environment Canada, Adaptation and Impacts Research Group, 2005, *Cities and Communities: The Changing Climate and Increasing Vulnerability of Infrastructure*.

[31] J. Bengtsson 2008, *Possible effects on buildings through climate change*

Table 1: Project and Asset Rating Guide – Climate Change Adaptation

Rating New Projects	Rating Existing Assets	Project Stage	Criteria	Performance Levels: Level 0 – Business As Usual	Level 1	Level 2	Level 3 – Project Leading Practice
Rating New Projects	Rating Existing Assets	Stage A: Planning, concept and design	1.Commitment	No reference by key stakeholder/ developer to climate change risks in project or asset documents.	Commitment by key stakeholder is publicly stated.	Commitment by key stakeholder included in the project's or asset's Key Performance Indicators (KPI)	KPI linked to corporate and contractual commitments of key stakeholder.
			2. Capability	Project team or operational team has no climate change risk management skills or experience.	Climate change risks managed by people who know how to respond to extreme events and have emergency management experience	Climate change risks managed by people with significant experience in this field.	Assessment made of staff barriers to adaptation to determine staff training needs in order to incorporate climate change implications into design and operations AND Delivery of relevant training to overcome barriers to adaptation AND Leadership in collaborating with local and regional stakeholders to build adaptive capacity of the whole infrastructure system.
			3. Climate change projections	No climate change projections used.	Desktop study undertaken to identify readily available projections for the project or asset region over the design life of the project or asset.	Desktop study undertaken to identify readily available projections for the project or asset region, over the design life including justification for selection of greenhouse gas emission scenario(s) and time scales used.	Desktop study as per Level 2 as well as interrogation or development of an appropriate model to obtain projections to inform specific project / asset design requirements and thresholds OR Justification why site-specific modeling was not required.
			4. Climate change risks assessed	No assessment of climate change risks.	Identify climate change risks to the project or asset over the (remaining) design life including construction and operating stages. Risk assessment process was consistent with current standard ISO 31000: 2009[34]; superseded AS/NZS 4360:2004 or AGO 2007.	Robust risk assessment considered direct and indirect climate change risks to the project or asset. Risk assessment process was consistent with current standard ISO 31000: 2009[34]; superseded AS/NZS 4360:2004 or AGO 2007. Internal project or asset stakeholders participated in identifying climate change risks and issues.	Risk assessment considered as per Level 2 along with flow-on climate change risks to the project or asset that have regional or whole of infrastructure system implications AND Comprehensive set of affected external stakeholders, who could include local government and representatives of other infrastructure utilities, participated in identifying climate change risks and issues.
			5 Adaptation options assessed	No options to treat climate change risks assessed	Adaptation options to treat all extreme and high priority (as defined in ISO 31000: 2009[34] or equivalent) climate change risks identified in the proceeding action and assessed for implementation.	Adaptation measures to treat all medium priority climate change risks identified and assessed for implementation AND Analysis of adaptation options informed by indicative benefits and costs (multi criteria analysis) for the project or asset. Evidence: as for previous Performance Level	Socio-economic cost benefit analysis of adaptation options to select best value measures to implement, as well as determining their optimal scale and timing (which may be triggered by when a specific climate or sea level threshold is likely to be achieved). Evidence: as for previous Performance Level
			6. Adaptation option designed or implemented	No measures to treat climate change risks	Adaptation measures to treat all extreme and high priority climate change risks included in the relevant final design plan, specifications and construction contract or operational plan (including periodic review and update of climate change projections and risk assessment).	Adaptation measures to treat all medium priority climate change risks included in the relevant final design plan, specifications and construction contract or operational plan.	Demonstrated innovation or new design standard recognised within relevant infrastructure sector.

[34] International Organization for Standardization 2009, *ISO31000 – Risk Management*, http://www.iso.org/iso/iso_catalogue/management_and_leadership_standards/risk_management.htm

	Rating Existing Assets	Project Stage	Criteria	Performance Levels			
				Level 0 – Business As Usual	**Level 1**	**Level 2**	**Level 3 – Project Leading Practice**
Rating New Projects		Stage B: Construction	6. Adaptation options designed or implemented	No consideration of climate change risks or adaptation measures during construction	Designed adaptation measures implemented for/ during construction. Draft operational plan finalised after being amended to reflect any changes made to designed adaptation measures during construction that would impact on their operational requirements.	Any changes made to adaptation measures during construction approved by designers.	Construction plans considered potential extreme weather events enhanced by climate change during construction.
Rating New Projects		Stage C: Commissioning	6. Adaptation options designed or implemented	No explicit consideration of climate change risks or adaptation measures when project is commissioned and handed over for operation	Operational plan and other project or asset documents detailing climate change risks and adaptation measures handed over AND Operational staff trained in operation of adaptation measures AND Testing to confirm performance of adaptation measures if relevant.	As per Level 1 with operational requirements for adaptation measures integrated into operating systems and policies AND Emergency management plans for project or asset site considering climate change risks	Commitment to implement adaptation options best suited to later in the infrastructures design life.
	Rating Existing Assets	Stage D: Operation	6.Adaptation options designed/ implemented	No explicit consideration of climate change risks or adaptation measures in operation of completed project or asset.	Climate change adaptation measures maintained or operated in accordance with the operational plan or other project or asset documents.	As per Level 1 and also monitor performance at pre-determined intervals and adjust adaptation measures, if required AND Monitor changes in climate and climate change projections AND Review and update climate change risk assessment with revised projections at least every seven (7) years	Understand and integrate implications of changing climate and impacts into business plan.
	Rating Existing Assets	Stage E: Decommissioning & Retrofitting	4. Climate change risks assessed	No explicit consideration of climate change risks or adaptation measures planned for proposed de-commissioning or retrofitted.	Review the assessment of direct climate change risks with extreme and high priority at site in context of de-commissioning to avoid climate change risks during and post de-commissioning of the asset.	Review the assessment of indirect climate change risks with medium, priority at site in context of de-commissioning to avoid climate change risks during and post de-commissioning. .	Review the assessment of flow-on risks at site and the surrounding region in context of de-commissioning to avoid climate change risks during and post de-commissioning AND Consider rehabilitation and retrofitting of the infrastructure to allow future use and thereby avoid any legacy climate change risks.

Glossary

Climate change vulnerability of a new infrastructure project or existing infrastructure asset is defined for this rating scheme as a function of the asset's exposure, sensitivity and capacity to adapt to projected changes in temperature, rainfall, sea level and other climatic variables. See Figure 2. The combination of exposure and sensitivity determines the *potential impact* of climate change on the asset. The *combination* of potential impact and adaptive capacity determines the asset's *vulnerability*.

Adaptation – actions in response to actual or projected climate change and impacts that lead to a reduction in risks or realisation of benefits[32].

Adaptive capacity – the capacity of an infrastructure system or organisation to adapt to climate change. This can be determined by factors such as knowledge, location and emergency management.

Direct risk – the chance of an impact (attributable to climate change) on an infrastructure system or organisation that causes damage, extra costs, accelerated deterioration or disruption of services provided. An example is increased storm or flood damage to infrastructure. Another example is buckling of railway tracks in extreme temperatures.

Exposure – the exposure of an infrastructure system or organisation reflects its location (region, elevation, aspect, proximity to sources of hazard such (coast, rivers, floodplain, forest, steep land etc.) and the direction and magnitude of change of the project's critical climatic variable(s). (AGO, 2007)[35] defines this as *the influences or stimuli that impact on a system - broadly it is the changes to climatic conditions that system will be exposed to.*

Flow-on risk – the chance of an impact on another system or organisation, two or more steps removed from your infrastructure system or organisation along the supply chain which, ultimately disrupts the supply of goods or services that your system or organisation critically relies upon. These are also called cascading or concatenating risks. For example, a severe drought exacerbated by climate change means that water cannot be released from upstream reservoirs to provide cooling water for downstream coal-fired power stations. The power stations are then obliged to drastically reduce power output. The resulting power restrictions force power-reliant industries to close or reduce production. Flow-on risks also include the chance of financial and other impacts resulting from regulatory and legislative changes (for example a Carbon Pollution Reduction Scheme), increased insurance premiums (caused by more extreme weather disasters) and society's auto-adaptive responses[37] to climate change (such as changes in behaviours, travel patterns, demography, technology and property values).

Indirect risk – the chance of an impact (attributable to climate change) on another system or organisation, which disrupts the direct supply of goods or services that your infrastructure system or organisation critically relies upon, thereby adversely impacting on your system or organisation. For example, power supply interruptions caused by excessive power demand during periods of extreme temperatures. Another example would be storm damage or disruption at a nearby port, which delays the delivery of urgently-needed equipment so that the infrastructure has to be closed or its services curtailed.

Resilience – the capacity of an infrastructure system or organisation to cope with, and quickly recover from, an adverse climate change impact. Resilience can be enhanced through changes in management, procedure and awareness, as well as physical measures[36].

Risk (climate change) – the chance of something happening (as a result of climate change) that have an impact (positive or negative) on achievement of an infrastructure system or organisation's objectives (AGO, 2006)[32].

Sensitivity – the sensitivity of an infrastructure system or organisation reflects the degree to which its physical condition or services are affected by changes in its critical climatic variable(s). (AGO, 2006)[32] defines this as *the degree to which a system is affected, either adversely or beneficially, by changes in climate related variables, including means, extremes and variability*.

Vulnerability -- the level of risk that remains once the potential impacts of climate change have been addressed as much as possible by adaptation.

35 AGO, 2007 – Australian Greenhouse Office 2007, Climate change adaptation actions for local government.

36 TRL, 2008 – Transport Research Laboratory, 2008, Climate Change Resilience Indicators, report for South east England Regional Assembly, CPR117, September

37 White Rand Cahill A, 2008, Climate Change and the Insurance Industry – no silver-bullet solution, The Zurich Report, Zurich Financial Services Australia Limited.

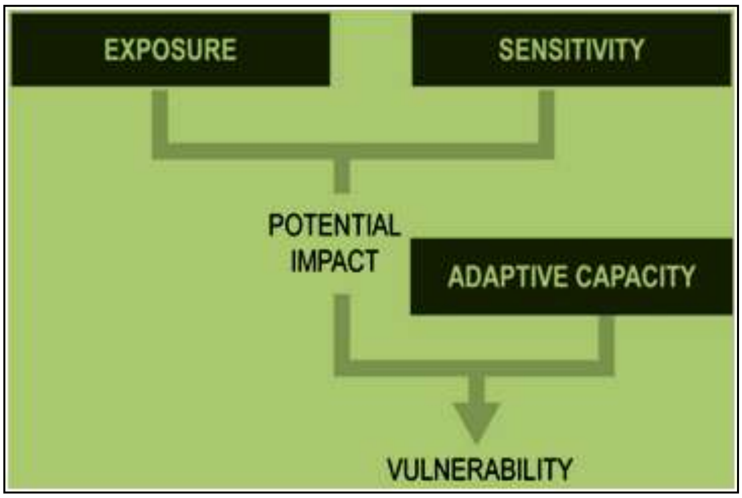


Figure 2: Components of Vulnerability

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