Climate Resilient Asset Management

In partnership with

IPWEA
INSTITUTE OF PUBLIC WORKS ENGINEERING AUSTRALASIA

SIEMENS

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Introduction

Across Australia, climate change is a constant topic of conversation – at the dinner table, in boardrooms, at council meetings, and in Parliament. Almost every day, there are news reports about extreme weather events and their impacts. Record temperature rises, rainfall totals, and flood peaks seem to have become the new normal.

In the last few years, heatwaves have swept through Europe, floods have inundated cities across Asia, and the Los Angeles wildfires became the costliest blaze in U.S. history. Now, scientists warn that the West Antarctic Ice Sheet is at serious risk of collapse: an event that could raise global sea levels by more than three metres.

Australia is also facing the impacts of climate change, and the pressure on our infrastructure is mounting. The **Black Summer Bushfires** of 2019–2020 resulted in 26 lost lives, devastated communities, significant damages of over A $2.3 billion, widespread environmental destruction and the loss or displacement of an estimated three billion animals[1]. In February 2024, storms across Victoria left more than half a million properties without power, and outages later affected over a million households. In early 2025, ex-Tropical Cyclone Alfred battered the Queensland and New South Wales coasts with winds over 100 km/h and rainfall up to 500 mm. Combined with a high tide, it produced three-metre waves – the largest recorded in 38 years on the Gold Coast – and shifted millions of cubic metres of sand along the coastline.

Assets, including physical infrastructure, buildings and natural systems, are highly exposed and frequently bear the brunt of these disasters. They also incur the most serious and expensive initial damage. Natural disasters cost the Australian economy around A$38 billion each year, and this is expected to rise to **$73 billion by 2060**[2]. For asset managers, this is changing the way we think about infrastructure planning and resilience. The question is no longer whether climate change will affect infrastructure assets, but how prepared we are when it does.

Historically, local governments and businesses have been reluctant to invest in climate adaptation. However, over the past century, Australia has seen sharp increases in extreme heat, bushfires, intense rainfall and severe flooding. As these events become more frequent and damaging, decision-makers are increasingly recognising that the cost of inaction far outweighs the cost of preparation.

This guide is designed to help asset managers integrate resilience into every stage of the asset lifecycle. It explores how to identify vulnerabilities, embed climate considerations into long-term planning, and plan for low-probability but high-consequence events – particularly when hazards overlap or occur in quick succession. It also highlights the role of Asset Management in disaster preparedness, including the capture and analysis of data before and after climate-related events to make faster, smarter, and more cost-effective decisions.

In a climate that is changing faster than at any time over the past 10,000 years, resilience can no longer be considered optional. Because some infrastructure has long useful lives (100 years or more), decisions made today will lock in either vulnerability or resilience for decades to come. The challenge, and opportunity, for asset managers is to ensure we are building infrastructure and communities that can withstand, adapt, and thrive in the face of a changing climate.

Understanding climate change risk

With climate change evolving so rapidly and with so many perspectives on the subject, it can be difficult to keep track of what we currently know and which sources to trust.

In Australia, the Bureau of Meteorology tracks extreme events and changes in the climate, providing a biannual State of the Climate report in collaboration with the CSIRO3. Internationally, the Intergovernmental Panel on Climate Change (IPCC) is the UN body responsible for assessing the science of climate change. Its sixth assessment report (AR64) builds on thousands of peer-reviewed studies, using robust scientific methods that combine observations, modelling, and process understanding.

What climate change modelling tells us today

What we know from lived experience and data from the BOM, CSIRO and IPCC is that climate change is already altering the operating environment for infrastructure assets. Global climate models also indicate that these impacts will continue to intensify.

But how accurate are the models? According to NASA[5], an evaluation of global climate models used to project future global average surface temperatures over the past half-century found that most were highly accurate, with no evidence of systematic overestimation or underestimation of warming.

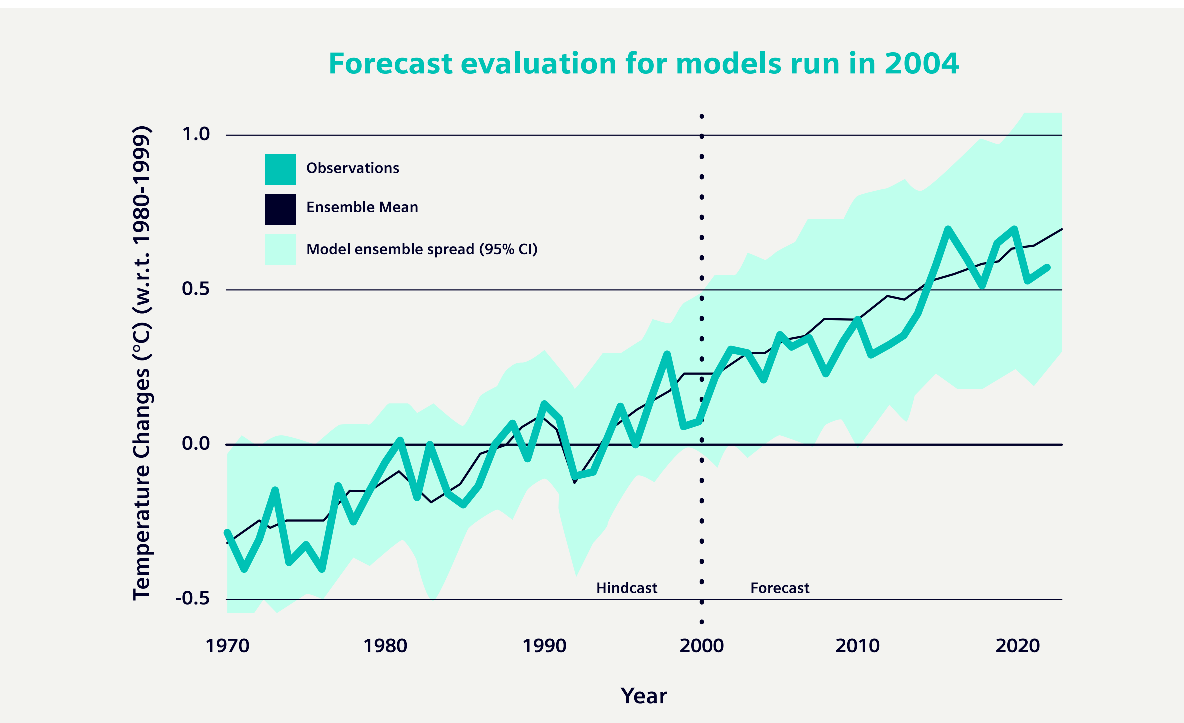

Figure 1: The NASA evaluation of global climate models shows that the observed temperature changes since 1970 have been accurately forecasted, and we can have confidence in their future projections. (Source: NASA.)

The lasting impact of carbon on climate

The science shows that global carbon dioxide (CO_2) emissions have not stabilised in any region. Since the Industrial Revolution, more than 1,800 billion tonnes of CO_2 have been released – nearly half of it since 2000. Around 70% of the warming since 1850 is directly linked to human activity, particularly the use of fossil fuels, transport emissions, and deforestation.

Importantly, today's warming reflects not only current emissions but also gases, released decades ago, that will remain in the atmosphere for centuries. This means that even in the most optimistic scenario, the IPCC projects continued warming until at least mid-century due to past emissions.

Assets in a warming world

Looking ahead, the challenges are steep. The Paris Agreement's ambition to limit warming to 2°C above the pre-industrial era by 2100 is now out of reach without dramatic global action. Current trajectories suggest at least 2.6°C of warming by century's end, with high emissions scenarios pointing to 3 – 4.5°C by 2100 and beyond to 6°C by 2150.

For long-lived assets designed to last decades and some into the next century, this places current infrastructure well outside its original climate design parameters.

Extreme heat events that used to occur once a decade are projected to occur multiple times within the same period. Tropical cyclones are expected to move further south as oceans warm, becoming more intense and destructive. Australia has warmed by over 1.5°C since 1910, with longer fire seasons, declining rainfall and streamflow across much of the country, more frequent heavy downpours, more consecutive extreme heat days, and more frequent droughts.

For asset managers, these changes underscore the need to integrate climate risk into every stage of the asset lifecycle, from design and planning to operation and disposal. It means not just preparing for physical damage but also all the impacts associated with a disaster, including service delivery issues, supply chain disruptions, budget pressures and community resilience.

Adaptation measures to mitigate risk

The next step is to understand how climate change will affect our infrastructure and to develop adaptation measures to mitigate risk. Here are the most significant hazards to plan for in Australia, and possible adaptation measures to consider.

Ocean acidification

One of the less visible but equally damaging consequences is ocean acidification. Roughly a quarter of global CO_2 emissions are absorbed by the oceans, turning into carbonic acid. Australia's oceans are acidifying up to 10 times faster than at any point in the last 300 million years. Acidic seawater doesn't just threaten marine ecosystems; it also weakens coastal infrastructure. Concrete structures, ports, and seawalls containing calcium carbonate are particularly vulnerable, as acid reacts with the material and reduces its strength, driving up repair and replacement costs.

Impacts

Accelerated degradation of concrete and cement-based structures leads to structural weakening of marine concrete, including in bridge pylons, seawalls, and port infrastructure.

Challenges

Shorter lifespan of marine infrastructure due to the cumulative effect of increased porosity and reinforcement corrosion.

Adaptation measures

- Monitor the condition of submerged port infrastructure more regularly
- Inspect underwater assets using Remotely Operated Vehicles (ROVs) integrated with Asset Information Management Systems (AIMS) for more accurate and detailed data
- Lower water-to-cement ratio to limit permeability
- Use Supplementary Cementitious Materials (SCMs) e.g. fly ash, silica fume or slag to refine the microstructure and lower porosity
- Properly cover steel structures by ensuring there is at least 5-7 cm of concrete over reinforcement.

Sea level rise, coastal erosion and storm surges

Given that one in two Australians lives within 7 km of the coast and that coastal tourism is a major part of the Australian lifestyle, the vulnerability of Australia's coastal infrastructure to sea-level rise, storm surges, and erosion is a major concern. Global mean SLR has been over 22 cm since 1900 with half of this rise occurring since 1970 (Figure 2). Global mean sea level rise has accelerated from a rate of 1.4 mm/ year (1901 – 1990) to 4.68 mm/ year (2013 – 2023). Global mean sea level rise in the 2022/2023 financial year was 7.5 mm. Sea levels around the north and south-east of Australia have been significantly higher than the global average. Events such as the East Coast Lows in 2015 and 2016 demonstrated how a single storm can cause severe property and beach erosion. The IPCC recommends basing urban planning and infrastructure decisions on projections that global sea level will rise by more than two metres by 2100.

Impacts

Damage or destruction from high winds and inundation of coastal assets including transport infrastructure (e.g., ports, jetties, boat ramps, coastal roads), buildings, energy generation and distribution networks with resulting loss of essential services, property losses and reduced tourism revenue.

Challenges

Resistance to coastal retreat, the long-term maintenance of protective structures, and uncertainty about the impacts of engineered defences on adjacent land.

Adaptation measures

- Invest in natural ecosystems (green infrastructure) like mangroves, salt marshes, coral reefs, and sand dunes to dissipate wave energy and provide a buffer
- Combine hard engineering with natural elements, such as buried seawalls under reconstructed dunes
- Install traditional engineered barriers like seawalls, dikes, levees, and storm-surge barriers
- Use GIS integrated with AIMS to map vulnerable topography and critical access routes
- Use Water Sensitive Urban Design (WSUD) principals to create parks and wetland storage zones (like Bangkok's Centenary Park) that absorb and store excess water during floods rather than letting it overwhelm city streets
- Prohibit new high-density developments in vulnerable zones and mandate shoreline setbacks.

Global sea level rise

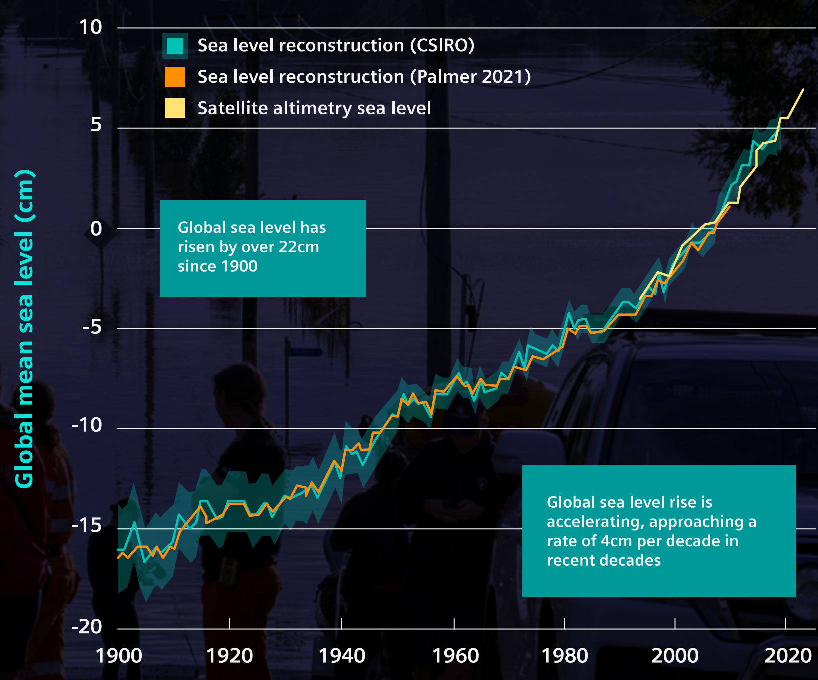

Figure 2: According to the State of the Climate 2024 report, global sea level has risen by over 22 cm since 1990. (Source: CSIRO)

Extreme rainfalls & floods

Flooding is becoming more frequent and severe across Australia, driven by a warmer atmosphere that holds more moisture, and leading to intense downpours and large-scale river floods. Observations show an increase in the intensity of heavy rainfall events in Australia. The intensity of short-duration extreme rainfall events has increased by around 10% or more in some regions in recent decades. The largest increases have been observed in the north of the country. Short-duration extreme rainfall events (such as high hourly total rainfalls) are often associated with flash flooding[2]. Flash flooding, once less common, is now occurring more regularly in both urban and rural areas.

Impacts

Loss of lives and homes, community isolation, power outages, transport and utility damage, accelerated asset degradation, overflow from stormwater systems, wastewater and septic tanks.

Challenges

Vast transport networks, balancing immediate restoration with long-term resilience, prolonged wet weather delays.

Adaptation measures

- Use robust flood warning systems such as IoT sensors in drainage systems and smart gauges to monitor water levels and trigger early warnings or automated gates
- Install levees and pump stations
- Complete Q100 (1-in- 100 years flood level)-standard upgrades for critical roads, elevate vulnerable structures and replace timber bridges with concrete
- Improve drainage and creek maintenance
- Encourage flood-proofing at property level
- Use advanced flood modelling to guide development

Bushfires, heatwaves and urban heat

Hotter, drier conditions are intensifying heatwaves that damage buildings, roads, utilities, and recreational facilities, while also placing heavy demand on energy and water systems. Drought and heat further weaken infrastructure by shrinking soils and destabilising foundations. In urban areas, heat is amplified by the "urban heat island" effect, where heat-absorbing surfaces like dark roads and roofs trap warmth, driving up local temperatures. This worsens the effects of climate change in cities, increasing risks to community health and wellbeing. With the frequency of dangerous fire weather days in Australia increasing, asset managers must also be prepared for the risk of bushfires. Out-of-control fires can cause catastrophic damage to both built and natural assets, with economic costs from major events exceeding billions of dollars.

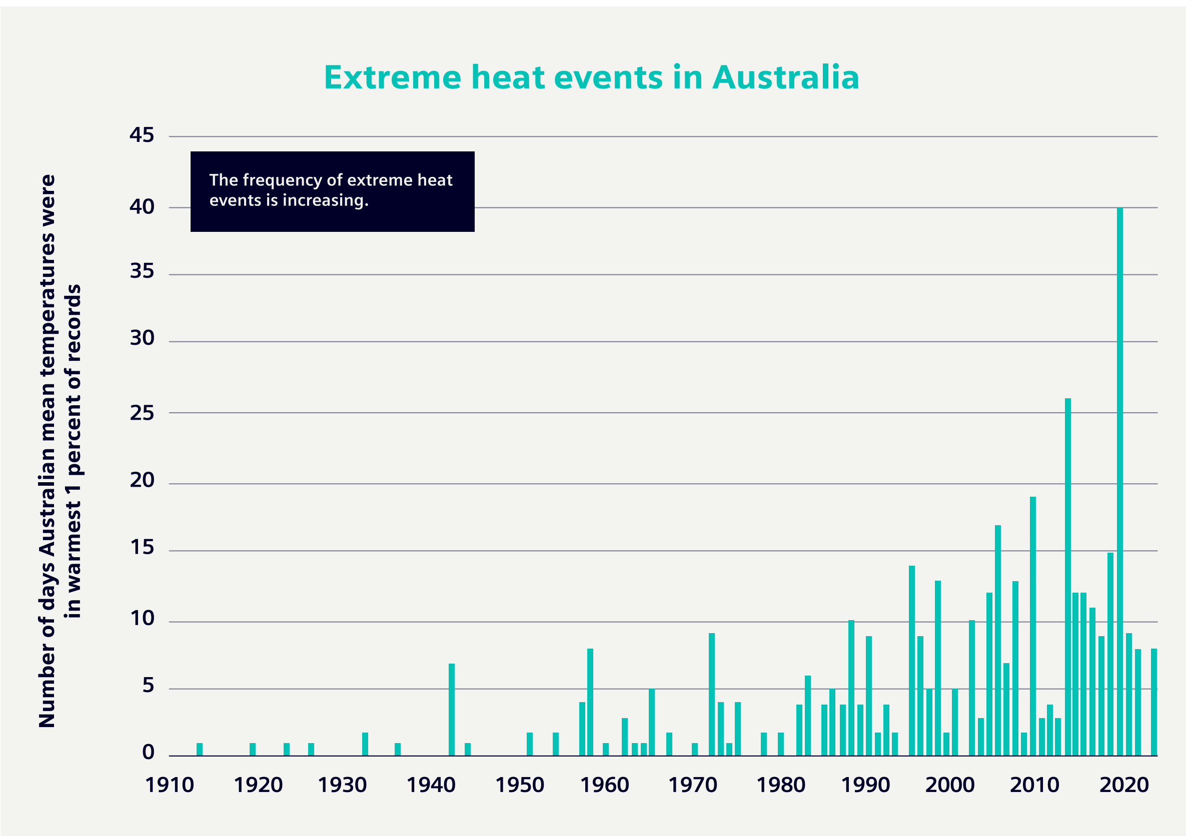

Figure 3: This graph from the State of the Climate 2024 report shows the number of days each year where the Australian area-averaged daily mean temperature for each month is extreme. Extreme days are defined as those where daily mean temperatures are the warmest 1% of days for each month, calculated for the period 1910-2023. (Source: Bureau of Meteorology)

Impacts

Greater health risks/loss of lives reduced outdoor activity, workforce fatigue, higher energy demand for cooling, increased rates of deterioration of exterior surfaces such as roads and buildings, loss of homes from fire, power outages, damage to critical assets, and poor air quality.

Challenges

Heavy loads on the power grid as a result of increased use of air conditioners, workforce fatigue during long fire and heat events, limited space for green infrastructure, uneven access to cool zones.

Adaptation measures

- Increase low flammability street tree plantings
- Use light-coloured, reflective and heat-reducing materials for roofs, roads, pavements and playgrounds
- Building design with passive cooling system and retrofit to improve energy efficiency
- Increase biodiversity in plantings to maximise cooling and expand tree canopy cover
- Maintain a fuel-reduced buffer or green firebreak between flammable vegetation and buildings to minimise flame contact
- Prevent ember attack with fire-resistant building codes
- Increase hazard-reduction burning
- Create shaded and water-cooled public spaces
- Ensure cool refuges and bushfire centres are fit for purpose and well maintained
- Accessible water fountains in public places
- Ensure accessible evacuation routes that allow for rapid civilian evacuation and emergency service access

Dangerous fire weather days in Australia

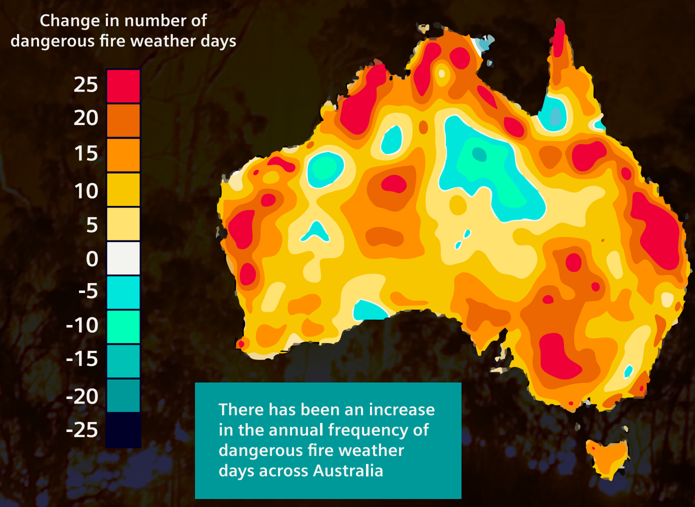

Figure 4: There has been an increase in the number of days with dangerous weather conditions for bushfires. This map shows the change in the number of days per year (July to June) that the FFDI exceeds its 90th percentage of conditions observed from 1950-2024. (Source: Bureau of Meteorology)

Planning for resilience

Asset managers play a critical role in reducing climate risk by embedding both emissions reduction and adaptation into long-term planning. Emissions reduction focuses on minimising the rate and scale of climate change by cutting greenhouse gas outputs in line with Australia's net zero by 2050 goal. This includes transitioning to renewable energy, increasing the use of zero- and low-emissions vehicles, reducing embodied carbon with cleaner manufacturing technologies, maximising or extending existing asset lives before building new ones, and adopting circular economy principles that reduce waste to landfill, improving resource recovery and green supply chains. Many actions deliver dual benefits by both lowering emissions and strengthening resilience, including energy-efficient and climate-responsive building design, water conservation, urban greening, and smarter, more adaptive infrastructure.

At the same time, asset managers must plan for unavoidable climate impacts with proactive adaptation strategies. This requires a systems-based approach across interconnected assets and services, and the integration of climate risk into urban planning and infrastructure design to accommodate projected sea level rise, increased bushfires, heatwaves, drought, intense rainfall and flooding. Adaptation involves deciding when to accommodate change, protect or defend assets, or retreat from high-risk locations, using a mix of no-regrets, low-regrets, win-win and flexible measures. Supporting community awareness, education and social services is also essential to ensure community expectations align with asset services in a changing climate.

Climate-resilient asset management also considers how traditional grey infrastructure can be complemented or partially substituted with green or hybrid solutions, such as wetlands, urban forests and permeable surfaces, to improve resilience, performance and whole-of-life value.

Three forms of resilience

Resilience is the capacity of communities, businesses, infrastructure, natural ecosystems, and the economy to adapt and respond to both short-term shocks and long-term stresses. In practice, resilience is the ability to anticipate, absorb, adapt to, and recover quickly from disruptive events.

Resilience comes in three forms:

1. **Asset resilience:** The ability of individual assets to withstand a disaster and repair the impact.
2. **Network resilience:** The capacity of entire networks or systems of assets to withstand a disaster event and provide continuing service.
3. **Community resilience:** The community's collective ability to prepare for, withstand, and recover from a disaster.

Resilience must be planned, designed, and embedded into assets, networks, and systems. When damaging events occur, the goal is not only to reduce risk and minimise impact on communities but also to ensure that renewed or replaced assets are designed to withstand future events across their lifecycle.

Five steps to building resilience

1. **Hazard identification and exposure**
   Know the hazards your assets are, and will be, exposed to.

2. **Vulnerability level**
   Assess how vulnerable assets are to the effects of these hazards.

3. **Quantify the risk**
   Use an ISO 31000 risk assessment process to determine the highest risks to focus on.

4. **Adaptation response**
   Identify the adaptation measures you can make to not only mitigate the highest risks but also strengthen long-term asset performance.

5. **Lifecycle resilience**
   Action resilience plans using the right technology and digital tools to create community, network and resilience through asset management: registers, inspections, work orders, maintenance history, valuations, reporting and predictive modelling.

Establishing pre-disaster strategies to minimise impact

Once climate risks are identified, plan to reduce the exposure and vulnerability to the hazard, mitigate impacts, and maintain service continuity under stress.

Building resilience into asset management means considering:

- **Community and organisational education**
- **Governance and decision-making frameworks**
- **Future demand in a changing climate**
- **Redefined levels of service**
- **Impacts on asset useful life**
- **Lifecycle analysis that accounts for hazard risk**
- **Integration of resilience into risk management and long-term financial planning**

Annual reviews of asset plans and renewal programs should also embed climate adaptation and mitigation measures into budgets, scopes, and delivery.

True resilience planning goes beyond disaster recovery. It means embedding proactive, pre-disaster strategies that minimise costly downtime, protect critical assets and services, and keep operations running in the face of disruption. This requires addressing two key dimensions:

Physical climate impacts

Assets face physical and chemical deterioration from changing rainfall, temperature extremes, and storm intensity, which can shorten useful life and drive-up maintenance costs. Green infrastructure may struggle to cope with prolonged droughts or heat events. And extreme weather increases risks to staff and service reliability.

Policy and financial impacts:

Shifting planning codes, increased climate risk reporting requirements (e.g., TCFD), net-zero targets, and emerging technology standards will drive changes in asset design, obsolescence, and renewal decisions. Rising insurance premiums, escalating recovery costs, and potential liability risks add further financial pressure to already stretched budgets.

To guide this work, asset managers can turn to established frameworks. ISO 14091 provides standards for climate change vulnerability, impact and risk assessment, while IPWEA's Climate Resilient Infrastructure Guideline offers practical tools for applying this in the field. Covering more than 200 asset types, it also details how climate variables – rainfall, temperature, wind speed, bushfire weather, sea-level rise – affect materials such as concrete, PVC, bitumen, steel and timber. It also includes adaptation options, maps, case studies, and a decision-tree worksheet to identify vulnerable assets and prioritise interventions.

By embedding these insights into pre-disaster planning, asset managers can shift from reacting to crises toward building infrastructure that is prepared, adaptable, and resilient for the long term.

Tools to support resilience planning

Global

- IPWEA International Infrastructure Management Manual
- Sustainable Asset Valuation (SAV)
- IPCC

Australia-wide

- Climate change in Australia
- National climate change risk assessment
- Coast Adapt
- Climate Resilient Infrastructure Guideline
- BriefEzy (SECCCA)
- IS Rating Tool (Infrastructure Sustainability Council)
- Bushfire Resilience Rating – Home Self-Assessment App (Resilient Building Council)
- XDI Climate Risk (https://xdi.systems/)

By state & territory

- NSW: NARCLiM: NSW and Australian Regional Climate Modelling
- ACT: CC1: Climate Trends
- VIC: Victoria's Future Climate Tool (VFCT)
- Melbourne: Asset Vulnerability Assessment (SECCCA)
- QLD: Queensland Future Climate Dashboard
- WA: Climate Science Initiative
- TAS: Climate Futures Climate Modelling Technical Report
- SA: South Australian Climate Projections (NARCLiM 1.5)
- NT: Climate Change in the Northern Territory

The role of Asset Information Management Systems (AIMS)

Modern Asset Information Management Systems (AIMS), coupled with predictive asset lifecycle modelling, empower organisations to transform raw data into smarter decisions. This applies to both anticipating disasters and effectively responding to them. When used effectively, these systems foster a resilient asset base by seamlessly linking every stage of asset lifecycle management: planning and design, acquisition, operation and maintenance, and adaptive reuse or disposal.

AIMS serve as a central source of data for asset information. They typically store and manage critical data such as:

Asset Classification: Type, function, and categorisation.

Physical Attributes: Measures, location, materials, construction date, design standards, and elevation.

Financials: Replacement costs, depreciation, and investment history.

Performance & Risk: Useful life, Levels of Service (LoS), condition, obsolescence, compliance, criticality, associations to other assets, redundancy, and Consequence of Failure (CoF).

This comprehensive information is essential for informed climate adaptation planning, robust risk mitigation, and efficient disaster response and recovery efforts.

Identifying risks and vulnerable assets

Asset information (e.g., location, elevation, materials, and design standards), when integrated with climate hazard data (e.g., flood zones, bushfire risk, sea-level rise projections), enables organisations to pinpoint assets most exposed to climate impacts and prioritise actions accordingly.

Further value is gained through integration with Geographic Information Systems (GIS). These allow organisations to visualise assets against various hazards such as floodplains, bushfire-prone areas, coastal erosion zones, storm surge extents, and earthquake risk areas. The spatial capability provides a clear view of assets at risk, supports the prioritisation of mitigation strategies, and facilitates faster operational decision-making both before and after disasters.

Meanwhile, condition monitoring sensors, connected devices, mobile inspection apps, dashboards, and lifecycle modelling tools all feed into a richer data environment, and support both long-term investment planning and immediate disaster response.

Taking actions to mitigate climate impacts

When asset data is linked with sustainability information – such as operational energy and water consumption (via metering) and embodied carbon in construction materials – organisations can identify and implement improvements in energy and water efficiency. This data is crucial when building new assets or retrofitting existing ones. It also supports decisions on using lower-impact materials and encourages recycling or reusing materials where feasible, all without compromising service delivery.

Capturing the right data before extreme weather hits

When applying for natural disaster relief funding, organisations often need to demonstrate not only what was damaged but also the pre-event condition and value of the assets. For instance, funding is far more likely if evidence proves a damaged community hall was a well-maintained facility rather than one already in disrepair.

An up-to-date asset register significantly aids this process. Organisations should also consider regularly adding date-stamped "before" photos to their registers. In the aftermath of a disaster, this data provides compelling evidence to strengthen funding applications and insurance claims.

For insurance purposes, organisations may also need to demonstrate that assets were built to required standards and maintained appropriately. Storing design specifications, maintenance records, and service history within an AIMS is therefore becoming increasingly important.

Using criticality frameworks to prioritise service restoration

After a disaster, organisations must quickly determine what to restore first – clearing roads, repairing bridges, restoring drainage, and reopening public facilities – while also managing a surge of community reports.

AIMS can support this through a criticality framework that helps triage damage reports and prioritise work based on service impact. For example, an arterial road may require restoration within 24 hours, while minor roadside assets can be scheduled later. By focusing on networks and service outcomes (e.g., hospital access routes), organisations can identify truly critical assets and allocate resources where they matter most.

Predictive modelling strengthens this further by helping organisations compare risk profiles and funding options. Rather than defaulting to "like-for-like" replacement, organisations can adopt "like-for-right" –selecting more resilient designs, alternative materials, or earlier interventions that reduce future risk.

Harnessing mobility for faster response

Mobile tools integrated with AIMS allow field crews to assess damage, raise requests, receive work orders, and update job status in real time – without returning to depots for paper-based processes. This capability has proven particularly valuable after major events, helping organisations manage spikes in service requests, reduce downtime, and accelerate recovery.

Access to safety-critical information on mobile devices – such as whether assets contain hazardous materials (e.g., asbestos) – also supports faster response without compromising worker safety.

Strategic planning and informed investment decisions

Strategic planning is essential not only for climate mitigation, but also for preparing for disasters and improving recovery outcomes. Many studies show that investment in adaptation provides substantially higher returns than relying primarily on post-disaster recovery spending.

Lifecycle modelling helps organisations:

Quantify long-term costs and benefits of resilience investments

Compare treatment and renewal options

Prioritise renewal, upgrades that reduce the likelihood and severity of failures

Shift from reactive repairs to proactive renewals, lowering total lifecycle cost while improving reliability and continuity of service

For example, modelling may show that existing stormwater drains will not cope with future rainfall intensity. Upgrading capacity now (e.g., $5 million) could prevent far larger losses from flash flooding and downstream asset damage.

Assets exposed to extreme events often deteriorate faster, reducing useful life and service potential. Although resilient materials may have higher upfront costs, they can deliver better long-term performance. Scenario modelling within predictive tools can help organisations test and communicate these trade-offs clearly.

Overall, AIMS enable organisations to link condition, risk, and performance data with climate projections and adaptation strategies – supporting evidence-based investment decisions. Dashboards can then communicate outcomes to stakeholders and help align investment programs with broader objectives such as net-zero commitments, low-carbon materials, and climate-resilient design.

Conclusion: Building resilience into the future of asset management

At every stage of the asset management lifecycle – identifying needs, planning, designing, building, maintaining, renewing, and ultimately recycling / disposing – asset managers must balance performance, cost, and risk associated with climate change. Asset management requires us to look beyond the immediate horizon and anticipate how a shifting climate will alter asset condition and performance in the decades to come.

Traditionally, assets were renewed at the end of their useful life. Today, however, extreme weather will push even well-performing assets to premature failure – and sometimes more than once over their expected useful life. This reality underscores why resilience planning is now a core principle of responsible asset management.

The challenge ahead is not whether to upgrade or replace, but how to do it like-for-right: investing in smarter, stronger, and more adaptive infrastructure that reduces vulnerability, minimises future rebuild costs, and sustains services through uncertainty – no matter what the weather throws at us.

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