Climate Change Adaptation
Good Practice - Case Study

Quantifying the Cost of Climate Change Impacts

About Adaptation Good Practice

Adapting to climate change is a relatively new concept to many. It is important to learn from practitioners who are undertaking adaptation activities that are beginning to have tangible outcomes. Documenting examples of good practice and identifying the criteria that makes them work, enables those interested in adaptation to learn about how to take action.

There are expectations that Adaptation Good Practice (AGP) includes a definite start and finish to a project. However climate change practitioners' experiences show that adaptation projects are often steps in longer learning journeys. There are no golden rules on how to adapt and often practitioners across Australia are inventing the wheel that drives future AGP.

This case study of Quantifying the Cost of Climate Change Impacts is part of a series of 16 case studies that recognise exemplars for AGP in Australia. Through the development of these stories of successful adaptation it was refreshing to see an emergence of similar experiences and challenges regardless of the project or location.

A synthesis of these stories can be seen in the Synthesis Report 'Climate Change Adaptation Good Practice: Key lessons from practitioners experiences', which which will help practitioners to understand that they are not alone in their challenges and to see some of the clear lessons learned about what drives good practice in adaptation.

Following the Snapshot is a more in-depth narrative of the experiences, learnings and network links to stimulate further engagements and knowledge sharing among the growing community of climate change adaptation practitioners.

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Case study snapshot

Quantifying the Cost of Climate Change Impacts

Australia's 560 Local Government authorities are responsible for the management of assets valued at approximately $300 billion (ALGA 2010). Many of these assets have a life span greater than 50 years and so will be affected by long-term shifts in the climate.

At date of publication, the maintenance and replacement of hard infrastructure by Local Government has been guided by the principles, models and tools provided in the International Infrastructure Management Manual (IIMM), developed by Institute of Public Works Engineering Australia (IPWEA) in conjunction with Councils, engineers and manufacturers of various components and materials. However, these tools do not incorporate climate change impacts or calculate the likely flow-on effects to asset maintenance and repair or financial management and so Local Governments have been limited in their capacity to estimate these changes.

This project had the aim of researching options and developing asset management tools for use by Local Government practitioners to incorporate the impacts of climate change on Council assets and infrastructure in corporate, asset and strategic planning processes.

Specifically, the key project objectives were to:

- Quantify the likely financial impacts to Councils for the maintenance and repair of road assets from expected changes in the climate to 2100.
- Focus on the development of tools that allow Councils to quantify the financial cost of climate change impacts on their assets.

The project journey

The Local Government Association of South Australia (LGA SA) Mutual Liability Scheme (MLS) conducted a climate change risk assessment, that identified roads as a major asset vulnerable to climate change risk. The LGSA turned this concern into an opportunity to submit an expression of interest (EOI) for funding from National Climate Change Adaptation Research Facility (NCCARF) through the Adaptation Research Grant Program's Settlements and Infrastructure call. An applied climatologist was asked to lead the project team and prepare the EOI. Funding was secured from NCCARF for this project to quantify the costs of climate change impacts on local government roads.

After project inception the project team found integrating climate, engineering and financial models to be difficult and complex but a series of full day project meetings regularly attended by stakeholders helped provide technical expertise. This positive collaboration and exchange of ideas among committed climate change practitioners and expert technical advisors helped drive the project and encouraged innovative adaptation practice. At the end of their learning journey, these engaged stakeholders realised that they would miss getting together again for further project meetings.

Figure 1: Map showing the location and names of collaborating Councils of Barossa, Campbelltown, Port Adelaide, Enfield and Onkaparinga in South Australia (SA); Bass Coast, Hume and Wattle Range in Victoria (VIC); Brighton in Tasmania (TAS); and Esperance in Western Australia (WA).

This positive collaboration and exchange of ideas among committed climate change practitioners and expert technical advisors helped drive the project and encouraged innovative adaptation practice.

Drivers for adaptation action

The LGA SA MLS identification of climate change impacts and risks to Council infrastructure, end user requests for climate change decision support tools for asset management.

The availability of NCCARF funding assisted in conducting the applied research.

No specific date or event led to adaptation action, just a change that occurred in response to the MLS report and the end users request for data led to expression of interest for funding.

→ Adaptation action

Effective integration of climate change risk considerations into financial, engineering and asset management tools.

Risks and impacts addressed

Impacts from changes to median temperature and rainfall on road assets (hotmix / asphalt, spray sealed and unsealed roads).

Outcomes achieved

Final project report; Financial simulation model that quantitatively calculates the impact of changes in temperature and rainfall on the useful life and maintenance costs for three major road types.

Emerging outcomes

Integration of the financial simulation model into the IPWEA National Asset Management Framework and tools.

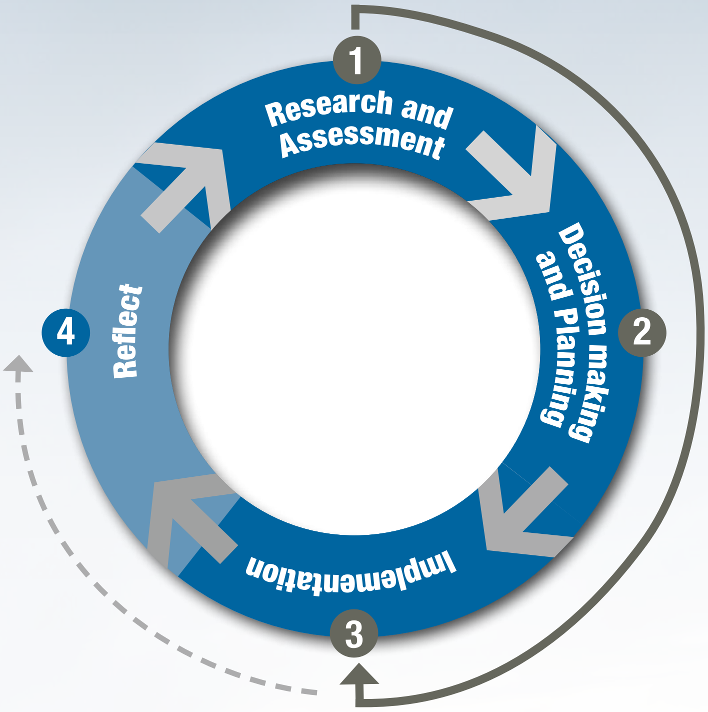


Figure 2: Quantifying the Cost of Change Impacts Adaptation Good Practice phase

The project

Ten collaborating Councils across South Australia (SA), Victoria (VIC), Western Australia (WA), and Tasmania (TAS) were involved in the project from the early stages (refer to Figure 1) and attended stakeholder meetings, provided input to the methodology, asset and financial data and gave feedback on the tools developed. Due to the various disciplines involved and the interactive, adaptive nature of the research, the initial intention to run the project in a linear, sequential manner was soon realised to be too simplistic and instead the project was coordinated so that all elements would progress in parallel.

Of particular interest for adaptation practitioners is how a complex multidisciplinary research process was initiated, supported, tested and then integrated into existing local government management processes and tools by the Councils and by asset manager end users in collaboration with a research team.

Source: Jacqui Balston

Figure 2: Networks created for this project

➔ Lesson learnt:

The initial intention to run the project in a linear, sequential manner was soon realised to be too simplistic and instead the project was coordinated so that all elements would progress in parallel.

Project engagement and collaboration with IPWEA and the case study Councils meant that end-user ownership of the outputs was high and there was a desire to extend the tools to a national scale.

Risks and impacts addressed

A review of infrastructure identified roads as the largest local government asset class by value and one for which engineering models are available that could quantify the impacts of climate. Climate variables that affect the useful life of roads include temperature and rainfall and so the likely changes for each of these variables to the year 2100 were assessed.

The impacts of changes to rainfall and temperature on road assets include changes to the useful life of the asset and altered maintenance and repair schedules with corresponding changes in cost. The methodology and software developed have the capacity to be extended in the future to include additional asset classes or climate variables.

Response strategy

This project was significant because it integrated three models (climate, engineering and financial) to ensure a multidisciplinary focussed outcomes could be achieved. This integration was made possible by holding monthly daylong project team meetings to which other technical experts were included when necessary to work through the complexities of integration as a team. In addition, a project website available to all project stakeholders was established to enable the sharing of technical reports and provide a space for online discussions. Regular communication and meetings meant that the project did not stall when one dimension of the work met difficulties and instead the full resources of the team were able to quickly find solutions.

Implementation phases

The first stage in the project involved a review of the climate changes already recorded and those that are likely for southern Australia out to the year 2100. Climate data for use in the development of the financial tool was identified.

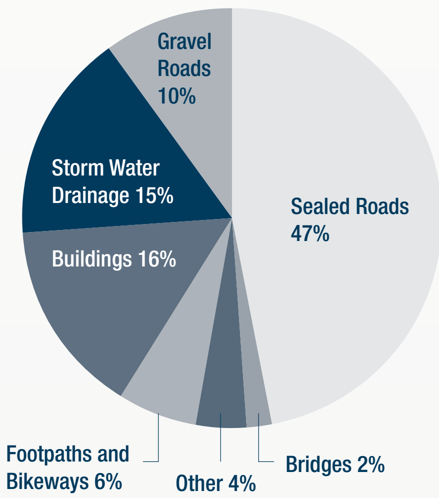
The second stage of the project involved a detailed review of the scientific and grey literature and detailed discussions with the LGA SA and IPWEA staff, technical personnel and key stakeholders on the deterioration of materials widely used in significant Council infrastructure construction. Roads represent approximately 60% of the value of Council assets (Figure 4). For that reason the development of a decision support tool that allowed Local Governments to translate climate change impacts on road assets into strategic and operational, financial and asset management plans focussed on the three largest road asset classes: hot-mix/asphalt sealed roads; spray-sealed; and unsealed roads. To support the development of a financial model, seven mathematical models that estimate road deterioration were reviewed and their appropriateness for application to the study evaluated.

Images supplied courtesy of the Local Government Association

Road asset around Port Augusta, SA

A relevant, validated model for each road asset type was selected and in each case temperature and/or rainfall parameters were required to model the impacts of climate change on the useful life of the asset.

The third and fourth stages of the project involved the development of the financial asset management model and tool. The model was developed in Microsoft Excel and was designed to integrate with the existing IPWEA asset management software tool National Asset Management Strategy (NAMS). PLUS. The model developed provides a clear, comparative analysis of the financial impacts of climate change for each of the three road types and uses Monte Carlo simulations and options pricing as methods of uncertainty analysis to deal with the highly variable



Source: Jacqui Balston

Figure 4: SA Local Government infrastructure asset stock 2006 based on dollar value. (Data from: OSLGR 2012)

nature of data inputs. Inputs to the model include the non-static components of climate change scenarios and impacts on the useful life of roads, and economic and price fluctuations.

Historical monthly temperature and rainfall data for the period from 1911 to 2010 were extracted from the Bureau of Meteorology (BoM) High Quality National Real Time Monitoring (RTM) gridded data set as an area averaged, monthly data set for each of the ten collaborating Councils. This data was then used to calculate long-term climate distributions for each of the four climate variables required for the models: mean monthly precipitation; monthly mean minimum temperature; monthly mean temperature and the Thornthwaite Index (a measure of soil moisture).

To keep the tool simple and avoid the need to update the data in it for each future climate scenario, the model was designed to be able to alter the mean and distribution of each parameter based on user defined climate changes. This approach allows the user to test the impact of any selected climate change scenario if the projected change in annual mean rainfall or temperature compared to the 1990 baseline is known. In the model, the climate change impact in terms of costs is determined as the difference between the total present value of costs with and without climate change. Using an annuity formula, these costs were also transformed into a quantified impact on road useful life.

The fifth and final stage of the project involved testing of the software tools with collaborating Councils by using their own real data. Data were obtained from Councils at site meetings, via teleconferencing and using electronic

Financial Model Steps

Select Council Name

↓

Select terminal climate projection year (up to 2100)

↓

Enter expected change to the climate by the terminal year:
Input change to mean annual temperature
Input change to mean annual rainfall

↓

Select road asset type (Asphalt/Hotmix, Sprayed Sealed or Unsealed)

↓

Input engineering parameters

↓

Run Climate Change Impact Financial Simulation Model

↓

Select Output: distributions for climate change impact in % for total costs, and useful life

↓

Enter output in the form of change in service life, change in asset life, or cost of maintaining current asset life into NAMS PLUS in the appropriate spreadsheets.

Figure 5: Financial model steps

Images supplied courtesy of the Local Government Association

Around Port Augusta

Source: Jacqui Balston

Cracked / potholed roads

communication. Key conclusions derived from the pilot modelling were:

1. Over the periods modelled the incremental impact of climate change on road infrastructure of all three types appears to be generally small and positive, with respect to both useful life and costs.
2. Results across Councils clustered around the mean for asphalt/hotmix and spray sealed roads, but across a significantly wider range for unsealed roads. Trends evident in the 2050 scenario were amplified for the 2100 scenario.

Outcomes achieved

The project was initiated in response to an identified climate change risk to Councils, and supported by Council asset managers and IPWEA.The project was successful in developing a rigorous model and user friendly input tool that are compatible with the current national IPWEA Asset Management Framework (or other Excel based asset and financial management tools) and that are able to calculate the changed cost of maintenance as a result of climate change on the three road asset classes modelled (Figure 5. The model is able to take into account the uncertainty associated with financial and climate fluctuations. Project engagement and collaboration with IPWEA and the case study Councils meant that end-user ownership of the outputs was high and there was a desire to extend the tools to a national scale.

In collaboration with IPWEA, a follow on project is currently extending the geographical range of the financial model to include a total of 75 local government areas across WA, SA, VIC, TAS and New South Wales (NSW) including each of the capital cities. The model will be run to the year 2100 for a range of projected climate changes under a high emissions scenario and the average annual change in useful life calculated. Results will be summarised in a look-up table and provided to road asset managers. The current version of the NAMS.PLUS software and website will be updated to incorporate the outputs of the financial model and workshops in WA, SA and VIC will introduce users of the tools to the project and demonstrate the outputs. Ongoing training in the use of the project outputs will be included in the national IPWEA NAMS.PLUS training package and updated versions of the software and website and made available for use nationally.

Emerging outcomes

Integration of the financial simulation model into the IPWEA National Asset Management Framework and tools.

Critical success factors

AGP analysis of the project

Success of this approach has been driven by strong leadership, excellent engagement and connectivity between all stakeholders, a sustainable vision and cost.

This project is strong in:

- **Leadership**
- **Engagement**
- **Connectivity**
- **Sustainability**
- **Cost**

Engagement within the project was high both internally and externally....researchers and key technical stakeholders were in constant collaboration to resolve the complexities of the project.

Leadership

The LGA SA MLS undertook a climate change risk assessment for every Council state-wide. The assessment is considered to be a foundation piece of work that provided each Council with identified climate change risks and the LGA SA with a rigorous scientific process on which to base climate change adaptation investment priorities. The LGA SA climate change strategy and partnerships with the State Government under the state climate change adaptation sector agreement provided the policy support for action. These two components meant it was possible for executive leaders in the LGA SA to endorse the project and contribute $200,000 funding support via the MLS.

Leadership within IPWEA meant that the project had the necessary sector level and technical support required and the ten collaborating Councils provided leadership in the form of financial and in-kind contributions to the project.

Councils and other key stakeholders including the BoM and Commonwealth Scientific and Industrial Research Organisation (CSIRO) also provided ongoing support and involvement by attending regular stakeholder meetings, sourcing technical data and testing the project outputs. IPWEA has taken responsibility for extending the project outputs beyond the end of the project by integrating the model into their existing NAMS.PLUS software and website and providing training and project support nationally.

→ Leadership lesson learnt:

Having a policy, sectoral, technical and and collaborative support enabled LGA SA to progress their adaptation investment priorities.

Engagement

Project team members included, an applied climatologist, road engineer, financial modeller, mathematician, computer programmer, town planner, economist and project manager. In addition, key stakeholders included asset managers, financial managers, Council personnel and climatologists. Agencies represented included LGA SA, SA Department of Transport and Infrastructure, SA Department of the Premier and Cabinet, IPWEA, BoM, CSIRO, University of South Australia (Uni SA), Murdoch University, Municipal Association Victoria (MAV), Western Australia Local Government Association (WALGA), ten collaborating Councils, and consultants (see Acknowledgements page 2).

Engagement within the project was high both internally and externally. Regular monthly project team meetings meant that researchers and key technical stakeholders were in constant collaboration to resolve the complexities of the project. A regularly updated project website with copies of key reports, meeting minutes and draft outputs was available to all project members. Annual full stakeholder meetings kept project partners up to date with progress and provided them with the opportunity to provide additional technical and enduser input and to design the project outputs to ensure that they would be practical and easy to use. Throughout the project regular emails, telephone calls, video conferencing and interviews kept project partners engaged and the communication flowing.

A web of new partnerships was made as a result of the project and conversations and collaborations are continuing at many levels (Figure 3). The supplementary project to extend the outputs nationally has again brought together key project team researchers and managers who will continue to

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engage with the original stakeholders as well as develop communications tools for a wider range of end-users.

Engagement lesson learnt:

New partnerships made as a result of the project. Conversations and collaborations are continuing at many levels.

Connectivity

Project outputs were designed to dovetail into existing local government asset and financial management planning tools including the IPWEA NAMS.PLUS software package and the LGA SA local government financial sustainability program.

The model developed as part of the project has the capacity to be modified to include other asset classes in the future, assuming there are the engineering models to support it.

The project was developed with a national focus so that outputs could be expanded to provide national coverage in the future*.

Connectivity lesson learnt:

Using inputs complementary to existing tools improved their utility and transferability.

Sustainability

The project has demonstrated that there is the capacity to integrate climate change into engineering and asset management tools, a previously unquantified risk. Project outputs meet intergenerational issues of sustainability by producing tools to estimate the likely impact of climate change on road assets into the future. Figures produced by the model are easily integrated into existing best practice financial and asset management tools.

Council asset managers nationally who use existing financial and asset management tools will now be exposed to the findings of this project by way of IPWEA tools and training, a process that will be continued into the future.

By producing user-friendly tools that integrate climate change into asset and financial management, asset managers will be made aware generally of the fact that climate change is likely to impact upon local government assets. In this way, the outputs of the project are considered to be the 'thin end of the wedge' in an emerging area of reform.

The financial model developed used the Monte Carlo Method and its simulation techniques to provide outputs that assist decision makers to deal with the uncertainties of climate change projections and financial inputs. The Monte Carlo Method is a process that calculates the range of possible outcomes and allows for better decision making under uncertainty.

Sustainability lesson learnt:

By producing user-friendly tools that integrate climate change into asset and financial management, asset managers will be made aware generally of the fact that climate change is likely to impact upon local government assets.

Cost

Total budget for the project was $740,000 including $320,000 from NCCARF, $230,000 from collaborators and $190,000 in-kind. Cost-benefit analysis of the project was not undertaken as the impacts of climate change to road assets had not been quantified and so benefits were not possible to assess. However, the LGA SA was confident in investing money into the project to address an identified risk to local government. IPWEA undertook a cost analysis when determining the most cost effective way to integrate the model developed into their asset management tools.

Ongoing costs associated with maintaining the asset management software and tools and associated training will be borne by IPWEA beyond the life of the research project. It is expected that further expansion of the deliverables to include other assets will be an investment by industry and end users in the event that they find the outputs valuable. The appropriate use of the tools will assist Councils to invest wisely into road maintenance programs and save money into the future.

Cost lesson learnt:

The tools can support council to make long-term focussed, cost effective decisions about future road maintenance programs.

* The supplementary project still has a Southern Australian focus (WA, SA, VIC TAS, NSW) Northern areas are not included

Conclusion

If possible modify an existing tool rather than create a new one. If industry already has tools and processes that are considered best practice, climate change adaptation research can be relatively easily integrated into these by 'value adding' to them rather than creating new ones that don't have a body of practicing users. In this way the uptake of project outputs can be rapid.

Multidisciplinary projects can be difficult to manage but they can lead to exceptional outcomes. The project demonstrated that it is possible to synthesise very complex, multidisciplinary inputs into a simple output that can be easily translated into existing systems.

→ Lessons learnt:

If possible modify an existing tool rather than create a new one.

Implement adaptive management processes.

Gaps and future challenges

The project was able to quantify the impacts of median changes in the climate to road asset useful lives, but, due to limitations in the engineering models, complexity in the asset class and interactions with other components such as bridges and culverts, there was not the capacity to model the impacts of extreme climate events such as flooding.

Challenges to the implementation of the project included the complexity of linking climate, engineering and financial models together to create a robust calculation of the impacts of climate change on an asset class. A lack of detailed engineering data collected by Councils on their road assets was also a limitation. In each case technical experts in the steering committee and project team were involved in resolving difficulties.

Links to more information and projects

- LGA SA Website:
  www.lga.sa.gov.au
- NCCARF Website:
  www.nccarf.edu.au/
- IPWEA Website:
  www.ipwea.org.au/Home/
- CSIRO Climate Adaptation flagship website:
  www.csiro.au/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/
- ClimateAdaptationFlagshipOverview.aspx
  Bureau of Meteorology climate change website:
  www.bom.gov.au/climate/change/

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NCCARF
National Climate Change Adaptation Research Facility

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