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FINAL PROJECT REPORT
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ECONOMICS OF NATURAL HAZARDS

Final project report

Veronique Florec, Abbie Rogers & David Pannell

The University of Western Australia & the Bushfire and Natural Hazards CRC

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EXECUTIVE SUMMARY

The key aim of our project was to provide evidence on the economic, social, and environmental impacts of natural hazards, in order to help hazard managers make better decisions about the allocation of resources for the mitigation of natural hazards impacts. Using the tools and materials we have created in this project, our end-users will be better equipped to estimate the tangible (market) and intangible (non-market) impacts of natural hazards and assess how mitigation investments may reduce those impacts.

With this aim in mind, our main focus has been the development of tools and materials that make it easier for natural hazards managers to estimate the value of mitigation, integrate intangible (non-market) values in economic analyses of mitigation, and evaluate the difference it makes to include non-market values. Our goal has always been to provide managers with the tools they need to be able to make better decisions and have the evidence to back up their decisions.

Our project delivered 5 key outcomes:

1. We launched an online platform for the Value Tool for Natural Hazards (a searchable database of the best available non-market value estimates relevant to natural hazards).
2. We conducted a non-market valuation study that filled a major knowledge gap identified in the non-market values literature (i.e. the values of cultural heritage, social disruption and mental health, and how these are affected by natural hazards) and updated the Value Tool with the data from this study.
3. We developed the Economic Analysis Screening Tool (EAST) for the evaluation of the (market and non-market) costs and benefits of mitigation options.
4. We created a Free Online Video Course on the economics of natural hazards, using drawings and simple examples to explain key economic concepts and how they are applied to evaluate different mitigation options.
5. We conducted an online training course on how to use economics in natural hazards management and delivered it to 4 different groups of end-user managers and practitioners.

All outcomes of the project had a utilisation focus and were developed in conjunction with our end-users. We spent a significant amount of time understanding our end-users' challenges in order to create products that can help them make better decisions using economic analysis. We used their feedback to improve the tools developed and make them more accessible.

The work from this project has been published in 4 peer-reviewed publications, 8 conference papers and technical reports, 3 posters presented at conferences, and 4 online resources (see Project Publications section in this report).

END-USER PROJECT IMPACT STATEMENT

Ed Pikusa, *Principal Risk and Audit Coordinator, Department for Environment and Water, SA*

This project has done an excellent job throughout its life in creating and maintaining an excellent relationship with its end users, while also focussing on producing high quality research.

The course of the project has adapted and changed to meet the needs of end users, and ensured that quality research was undertaken along with ensuring that the outputs were relevant and accessible.

I commend the project team, and the community of end users, in working well together and producing a suite of accessible products and knowledge on the economics of natural hazards.

This continues to be an important area of research, and over time, with increased predicted impacts from natural hazards, will continue to play important role in planning mitigation strategies.

PRODUCT USER TESTIMONIALS

Amanda Lamont, *Emergency Services Volunteer, Volunteer Firefighter, Emergency Management Advisor, Australian Red Cross, Country Fire Authority, VIC*

Thanks Abbie and Veronique. I am blown away at the quality and professionalism of this course, how well it has been delivered and the sheer complexity of the tool you have developed and shared. I am keen to review all we have discussed and think of the translation into words of the numbers, to be able to tell the story. Incredible work. Thank you so much for sharing. I have a degree in Economics - but it was never this much fun back at Uni! Research utilisation at its best.

Peta Turner, *Program Leader Capability and Resilience; Risk, Capability and Analysis, Department of Fire and Emergency Services, WA*

I found the course to be excellent – well run, useful and informative. This has been fantastic. I'm a newbie to economics and it has been very worthwhile. I can see many practicalities for implementing it.

Michael Griffith, *Professor of Structural Engineering, University of Adelaide, SA*

We really like the work you are doing and we need the information from your project to be able to include intangibles in our own economic analyses of earthquake mitigation.

Geoff Morris, *Senior Program Manager - Bushfire, Country Fire Authority, VIC*

Your work is very interesting and very necessary for us to be able to conduct comprehensive analysis of mitigation options that include both tangible and intangible values. In Victoria we are just working on doing that at the moment, evaluating the costs and benefits of different mitigation options for bushfires and we will need the type of work that you are doing in our analyses. It would be very good if we could include intangible values in our benefit-cost analyses.

Paul Simpson, *Principal Policy Officer, Office of Bushfire Risk Management, Department of Fire and Emergency Services, WA*

Just watched your video and found it very useful for understanding the different ways to measure economic inputs against outcomes and the different ways they are measured. I find the drawings concept more engaging than a PPT style. The commentary combined with the drawing at the same time kept me focussed on the screen and the words.

Glen Daniel, *Assurance Program Manager, Office of Bushfire Risk Management, Department of Fire and Emergency Services, WA*

I'm supportive of this idea, I think economic analyses are not well understood and having some basic educational material like this video will be really helpful. I liked the format, it was clear and engaging. I'd support the drawings over a PowerPoint type approach, which can be a bit dry. The content was pitched at a good level for me, instructive but clearly understandable. I say carry on and finish the series off!

Ian Fitzpatrick, *Manager Network Risk Strategy, Essential Energy, NSW*

Love this concept. Thank you for allowing me to review. It is a wonderful idea and I look forward to the series.

Rachel Armstrong, *Evaluation and Strategy Analyst, Community Preparedness, Department of Fire and Emergency Services, WA*

Thanks for this. I like this format, and the video does a good job of simplifying some complex concepts. It's kind of an overview, and I'd like to see more detailed treatment of each of the methods in subsequent videos – I'm sure that is coming.

INTRODUCTION

Although the potential to use economic evaluation to support decision making in natural hazards management in Australia has been discussed for many years (at least since the 1980s, e.g. Healey et al. 1985; Loane and Gould 1986, Thampapillai and Musgrave 1985), in practice, economic information is still rarely used in decision-making about natural hazards mitigation (Clayton et al. 2014, Jonkman and Dawson 2012, Ramm et al. 2017). This is primarily due to: 1) natural hazard managers have little familiarity with economic techniques and generally do not use economic information in decision making, apart from information on the resources and budget available (Clayton et al. 2014); 2) local governments do not always have the technical resources necessary to apply quantitative evaluation methods (Ramm et al. 2017); and 3) natural hazards have received varying attention from economists. Floods have been more studied than other hazards from an economic perspective, particularly for structural measures (Meyer et al. 2012), while economic research on mitigation for other hazards, such as bushfires and coastal hazards, have received less attention (Mercer et al. 2007, Ramm et al. 2017).

In addition, intangible impacts (also called non-market impacts) are rarely included in economic evaluations of natural hazards mitigation (Markantonis et al. 2012, Meyer et al. 2013, Rogers et al. 2019), which can lead to incomplete and biased assessments and, as a result, decisions that do not simultaneously maximise the benefits for society, the environment and the economy. Non-market impacts are rare included in economic assessments of natural hazards mitigation due to the limited transferability of available non-market value estimates to the natural hazard context and the very limited number of non-market valuation studies conducted in a natural hazard context (Rogers et al. 2019). To make sure that managers have a full picture of the costs and benefits of natural hazards mitigation that accounts for the tangible and intangible impacts, there is a need for more non-market valuation studies that are context-specific (to natural hazards) and provide a more accurate selection of value estimates for natural hazard decision making (Rogers et al. 2019, Markantonis et al. 2012).

In order to support better decision making in the natural hazards management space in Australia, there is a need to: 1) develop skills and capacity in the area of strategic decision-making (Young and Rogers, 2016), including economics (Clayton et al. 2014); 2) improve the collection of data about risk and potential impacts so that managers can use better information to inform strategic and operational decision-making (Royal Commission into National Natural Disaster Arrangements, 2020); 3) facilitate the inclusion of non-market values in economic assessments of natural hazard impacts and improve the capacity of managers to use existing values in their decision context; and 4) facilitate the adoption of quantitative evaluation methods within local government and the emergency management sector to have more accountable decision-making (Department of Home Affairs, 2018). Having accountable decision-making is one of the key priorities of the recently released National Disaster Risk Reduction Framework (Department of Home Affairs, 2018). Given that it is not possible to reduce all identified risks, the National Disaster Risk Reduction Framework presents a strategy to prioritise risks and identify the best mitigation opportunities, so that

investments in mitigation are targeted and the hazards with the greatest potential impacts are mitigated first.

With this in mind, we developed a research project with our end-users to address the needs above and support better decision making for natural hazards mitigation in Australia. The key aim of our project was to provide evidence on the economic, social, and environmental impacts of natural hazards, in order to help hazard managers make better decisions about the allocation of resources for the mitigation of natural hazards impacts. With our work, we seek to help land management agencies, and more broadly the emergency management sector, better prioritise their investments in mitigation. Using the tools and materials we have created in this project, our end-users will be better equipped to estimate the tangible (market) and intangible (non-market) impacts of natural hazards and assess how mitigation investments may reduce those impacts.

In previous work with the BNHCRC (2015-2017), we developed a tool for generating estimates of the intangible impacts of natural hazards and the intangible costs and benefits of hazard mitigation (called the Value Tool for natural hazards). We also produced two integrated economic analyses of management options (including intangible costs and benefits): one for floods in Adelaide and one for prescribed burning in private land in the Mount Lofty Ranges of South Australia.

In this project (2017-2020), we built on this work and developed tools and materials that will help agencies conduct and utilise more rigorous economic analyses of management options and identify the options that generate the best value for money. These new tools, which consider both market (tangible) and non-market (intangible) values, have met important end-user needs. Our goal has always been to provide managers with the tools they need to be able to make better decisions and have the evidence to back up their decisions.

BACKGROUND

In 2014, the Productivity Commission's report on natural disaster funding arrangements in Australia (Productivity Commission, 2014) found that governments overinvest in post-disaster reconstruction and underinvest in mitigation activities that would limit the impact of natural disasters. More recently, the CSIRO report on Climate and Disaster Resilience (CSIRO, 2020) found that to enhance resilience against natural disasters in Australia, we need to improve the tools used to make long-term strategic planning and investment decisions. Given the multitude of natural hazards that require mitigation and response from government agencies and the tighter budgets at both State and national levels, natural hazards managers are increasingly under pressure to justify the use and allocation of resources for mitigation efforts.

In addition, total economic costs of natural hazards in Australia are forecasted to increase significantly in the next 30 years and could potentially triple between now and 2050 (see Figure 1). This highlights the importance of establishing appropriate funding arrangements for mitigation of natural hazards in our country and making sure that those funding arrangements provide the highest benefit per dollar invested to society and the environment.

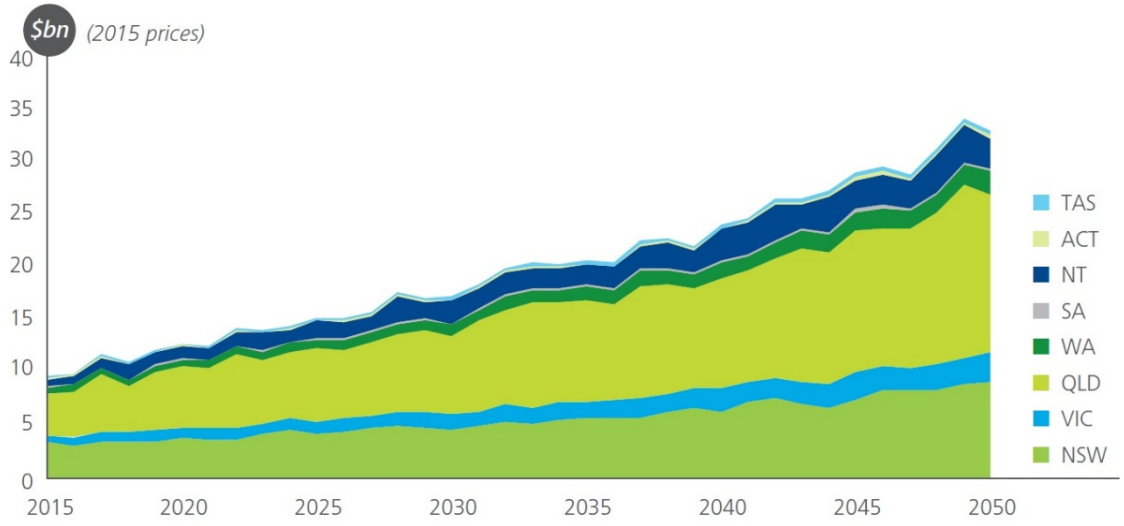

FIGURE 1. 2015–50 FORECAST OF THE TOTAL ECONOMIC COST OF NATURAL HAZARDS, IDENTIFYING COSTS FOR EACH STATE (SOURCE: DELOITTE ACCESS ECONOMICS 2016).

STRATEGIC CONTEXT

Governments need to ensure that the benefits of mitigation justify the costs and that they are getting the best value for money out of mitigation activities. To ensure that government decisions are informed by analyses examining the value for money of different alternatives, more economic analyses are needed in the natural hazards field.

By bringing more economic knowledge into the natural hazards sector, our project has helped address four major issues in the sector:

1. To this date, economic analyses of natural hazard management options remain rare for some hazards (e.g. bushfires) or incomplete in their

coverage of the different types of costs and benefits (i.e. intangible values are rarely taken into account). See Box 1 below.

2. Many (and in some cases the majority) of the impacts from natural hazard management are intangible (see Figure 2), but they are often excluded from economic analyses.
3. There is a general lack of information to carry out economic analyses and a shift in thinking is needed among land management agencies to ensure that more data is available (and useful) for economic analyses.
4. There is a lack of economics capacity in the sector. Natural hazard managers generally have little familiarity with economic techniques. Apart from budgeting information, they tend not to use other economic information and seldom revert to economic analyses for support in their decision making. As a result, decisions pertaining to natural hazards management are rarely informed by formal economics analyses.

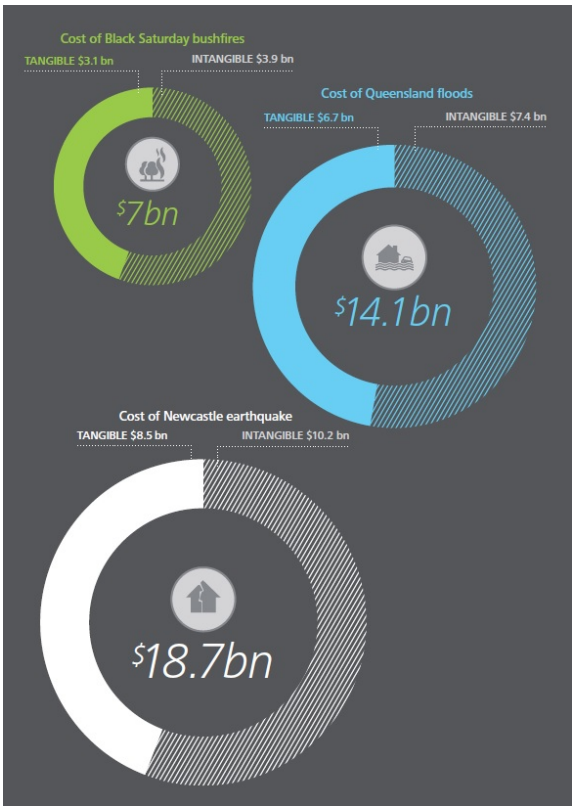

FIGURE 2. ESTIMATED TANGIBLE AND INTANGIBLE COSTS OF THREE MAJOR EVENTS (SOURCE: DELOITTE ACCESS ECONOMICS 2016).

Box 1. Research into the economics of natural hazards mitigation

Amongst all natural hazards, floods have received more attention from economist globally than any other hazard and there are more economic analyses of mitigation for floods than for any other hazard. This is partly explained by the fact that in the last 20 years, floods have been the most common natural disaster worldwide. Furthermore, on average, floods are the third most damaging natural disaster worldwide in economic terms (after earthquakes and cyclones) and flood mitigation measures usually involve large infrastructure investments that require to be properly assessed through benefit-cost analyses in order to justify their construction with government funds. With regards to flood mitigation measures, there has been a lot more economic research into structural measures (i.e. large infrastructure works such as dams, levees and culverts) compared to non-structural measures (e.g. warnings, evacuation systems, land use planning), mostly because there are well-established methods to evaluate the costs and benefits of structural measures, but there are few such methods to evaluate non-structural measures.

Earthquakes have received moderate attention from economists, particularly for cost of impact assessments and evaluating the costs and benefits of early warning systems. There are fewer economic analysis relating to bushfires and coastal hazards, though the number of studies has increased in recent years with increasing concern about bushfire incidence, coastal erosion and sea level rise worldwide. In bushfire economics research, most of the published studies have created models that use the same value per hectare for all hectares in the landscape (which is not true in reality) or estimate the reduction in risk levels achieved by a particular mitigation investment but do not convert this risk reduction to benefits in dollars (to be able to compare them with the costs). Research into the costs and benefits of coastal hazards mitigation has shown that short-term adaptation using coastal armouring responses ignores long-term intangible values, such as beach recreation and coastal ecosystems. Recent studies have included recreational values in their analyses, but there is still a gap when it comes to the ecological services provided by beaches.

Heatwaves and tsunamis have received very little attention from economists, mostly due to the nature of these hazards. Heatwaves cause large numbers of deaths, which are an intangible value, but are not as damaging to tangible assets as other hazards (e.g. floods and bushfires). Tsunamis, despite their potential for substantial damage, occur much less frequently and tend to be analysed by economists in countries where they have occurred or have a high chance of occurring (e.g. Japan, Indonesia) but are mostly ignored in places where they are less expected, even though they could still occur (e.g. Australia).

One of the key gaps in research on the economics of natural hazards is that most studies include tangible (market) impacts but tend to omit intangible (non-market) impacts, so a lot of the economic assessments available only show a partial picture of the total impacts. While non-market valuation research is abundant, it has rarely been done in the context of natural hazards. Most economic assessments have had to rely on non-market estimates from other contexts and transfer them to a natural hazard context, which reduces the accuracy of the estimates. There is a need for more non-market valuation studies that are specific to the natural hazards context.

RESEARCH APPROACH AND OUTCOMES

The focus of our project has been the development of tools and materials that make it easier for natural hazards managers to estimate the value of mitigation, integrate intangible (non-market) values in economic analyses of mitigation, and evaluate the difference it makes to include non-market values. This information will help managers in their decision making and resource allocation. The objective is for our end-users to have tools that they will be able to use without the need for continuous assistance from researchers.

Initially, our project was set to deliver 4 key outcomes. We proposed a new utilisation outcome (a training course), which was amended to the original contract towards the end of 2020. Our project delivered the following 5 key outcomes:

1. An online platform for the Value Tool for Natural Hazards.
2. Improve the Value Tool with new knowledge.
3. Development of the Economic Analysis Screening Tool (EAST).
4. A free Online Video Course on the economics of natural hazard.
5. A training course on how to use economics in natural hazards management.

The aim, background, approach and result for each of these outcomes is described below.

ONLINE PLATFORM FOR THE VALUE TOOL FOR NATURAL HAZARDS

Aim

To provide an online platform for the Value Tool that will be updated and maintained beyond the project so that managers can easily integrate intangible values in their analyses. The online version of the Value Tool can be accessed here.

Background

Prior to the commencement of this project (between 2015 and 2017), we developed the Value Tool for Natural Hazards, which is a searchable excel database of the best available non-market values compiled from existing studies that are suitable for use in benefit transfer for natural hazard decision making.[1] We integrated these values into benefit-costs analyses and case studies on flood management, prescribed burning, and earthquake impacts. The guidelines of

[1] Conducting new, original non-market valuation studies is the preferred approach for providing information about non-market values. However, sometimes original studies are not feasible or justified (e.g. the timeframe of a policy decision does not allow for the collection of new data, or the budget for the analysis is too small, or the decision to be made is a relatively minor one). In such cases, benefit transfer offers an alternative to conducting an original study. **Benefit transfer** is the process through which the results (i.e. the non-market value estimates) of an original (peer-reviewed and published) non-market valuation study are extrapolated to predict values for a different case study area.

the Value Tool explain how to use these values in benefit-cost analyses and how to adjust them to a different context (different from the context in which the values were originally estimated). But because of the large amount of information that is included in the Value Tool database, the user needs to apply several filters in the excel spreadsheet in order to find the most appropriate value. Depending on what the user is looking for and their understanding of what is measured by non-market values, this process can be complex. Therefore, end-users asked for an easier way to access the Value Tool and filter through the different values available. After several discussions with the BNHCRC, we decided to convert the Value Tool into an interactive online searchable database that makes it easier for users to find the values they need and makes the tool more accessible.[2]

Approach

After discussing different options with the BNHCRC, we concluded that this job needed to be done by an experienced web developer that could create a simple interface and stored all the data from the Value Tool in the background. The BNHCRC gave the task to one of their developers to convert the Value Tool into an interactive online searchable database. We worked closely with the developer and the BNHCRC team to get the online version of the Value Tool to a point where it was easy to use while also providing the key data from the Value Tool. We checked several times the online searchable database to ensure that when the search function was used, it returned the results sought and the exact same results that the excel version generates.

Results

The interactive searchable online database version of the Value Tool has been completed and is available from the BNHCRC website on this link:

https://tools.bnhcrc.com.au/valuetool

The Value Tool for considers 11 types of non-market values that are commonly affected by natural hazards or their mitigation. These are grouped by health, environmental and social-related values (see Table 1).

[2] The studies included in the Value Tool were selected using a set of criteria we developed, using guidance in the literature and consulting with experts in benefit transfer (see list of criteria below). First, we conducted a keyword search with keywords relating to non-market valuation (willingness to pay, choice modelling, choice experiment, contingent valuation, preferences, non-market values, etc.) and natural hazards (natural disaster, bushfire, wildfire, flood, flooding, earthquake, cyclone, storm, etc.). With the studies found, we used the following criteria to prioritise the selection of studies most relevant for inclusion in the database (with studies meeting the first criterion being the most relevant): 1) Values from an original Australian study, in the context of a natural hazard; 2) Values from a meta-analysis that includes Australian studies, in the context of a natural hazard; 3) Values from a meta-analysis that includes Australian studies, in a general context; 4) Values from an original Australian study, in a general context; 5) Values from an original developed country study, in the context of a natural hazard; 6) Values from a meta-analysis of developed country studies, in a general context; and 7) Values from an original developed country study, in a general context. Studies that did not include monetary value estimates were excluded.

Value type	Outcome measured
Health values	
Physical health	Change in the number of ***fatalities*** Change in the number of ***serious injury, hospitalised injury*** *and* ***minor injury*** Change in the number of ***illnesses*** or ***diseases*** Change in ***pain*** to an individual
Mental health	Change in reported cases of ***grief, stress and anxiety*** Change in the number of ***fatalities*** (due to self-harm)
Environmental values	
Ecosystems	Change in the number of flora and fauna ***species*** Change in the number of identified ***endangered species***. Change in the status of identified ***endangered species***. Change in ***native vegetation*** coverage Change in status of ***ecosystem function*** Change in status of identified ***threatened ecosystems*** Change in ***carbon storage*** in vegetation and soils
Water quality	Change in ***riparian vegetation*** coverage Change in ***condition of waterways***
Social values	
Recreation	Change in ***recreation activity*** within the area
Amenity	Change in ***scenic amenity*** of the area
Safety	Change in the ***perceived safety*** of a dwelling's location or construction
Cultural heritage	Change in ***Indigenous heritage significance*** Change in ***European heritage significance*** Change in ***heritage related recreation***
Social disruption	Change in ***moveability,*** such as traffic and public transport Change in availability of ***basic services***, such as electricity outage Number of ***displaced people*** away from people's homes and work places
Animal welfare	Displacement, death or injury to ***animals***

TABLE 1. VALUE TYPES INCLUDED IN THE VALUE TOOL.

The Value Tool comprises two elements that work together to allow decision makers to obtain financial estimates of the intangible values affected by natural hazards or their mitigation:

- The **Value Selector:** this is the database of intangible values. The Value Selector can also be downloaded in its original Excel file version from here.
- The **Guidelines** for the Value Tool for Natural Hazards: the guidelines provide guidance on the importance of intangible values, how to locate relevant values in the database, how to use these values, and how to adjust the database values for use in a particular decision context. They can also be downloaded from here.

Limitations

We recognise that the non-market valuation literature is incomplete with respect to providing highly accurate value estimates for all of the value types that might be affected by a natural hazard. However, we advocate that the use of an approximate number is usually better than no number, when it comes to decision making. It is better to have some information about the intangible benefits of a decision, than to ignore them completely: the error, and decision bias, resulting from the latter is likely to be far greater than the error from using an inaccurate number.

The benefit transfer method has its limitations and many of the studies available in the Value Tool have been ranked low in terms of their benefit transfer applicability. In some cases, where a value transfer is too unreliable, we don't recommend using the values in a quantitative analysis, but suggest using them in a qualitative manner to inform thinking about particular policies.

IMPROVE THE VALUE TOOL WITH NEW KNOWLEDGE

Aim

To fill major knowledge gaps identified in the literature on intangible values that are affected by the management of natural hazards.

Background

The development of the Value Tool required an extensive literature review of existing studies measuring the intangible values affected by natural hazards and their management. In undertaking this review, some important knowledge gaps were identified in key areas such as the environment (e.g. ecosystems, water quality), basic services, mental health, cultural heritage and animal welfare, as well as a lack of Australian non-market valuation studies specifically related to natural hazards.

Approach

To ensure the ongoing relevance of the Value Tool for natural hazard managers, we addressed some of these knowledge gaps by conducting an original non-market valuation study in Australia, directly related to natural hazards. This study estimates the values of cultural heritage, basic services and mental health and how they can be affected by earthquakes. In this study, we distributed a survey to more than 1,000 people in Perth and York, Western Australia, and presented them with a set of choices to select from. The choices varied in terms of the amount of money they would have to pay in order to reduce the level of damage caused by a large (magnitude 6 or 8) and a moderate (magnitude 5 or 6) earthquake to historically significant buildings in York, the amount of social disruption that would result (i.e. disruption to utilities and services for the local community and visitors to York), and the impact on people's wellbeing and mental health. A statistical analysis was conducted on the choices of all respondents in order to estimate the amount that a household is, on average, willing to pay to avoid these impacts, and the differences in how they value each

of these intangibles – cultural heritage, the continuous provision of basic services, and mental health.

Results

We found that the willingness to pay is statistically significant and positive for all three of the non-market attributes. Respondents were willing to pay the most per heritage building saved ($195 per household for respondents from Perth and $297 per household for respondents from York). Respondents from Perth were willing to pay $65 for each day of avoided disruption to services and utilities for the Town of York, while respondents from York were willing to pay $133. Respondents from Perth were willing to pay a little over $2 to avoid an individual suffering a mental health challenge, while the results for York respondents were not statistically significant. These estimates can be used for York or for other case study areas (using benefit transfer). To obtain the aggregate willingness to pay (i.e. total), we multiply these estimates by the number of households in the case study area that could be affected by these disruptions. Depending on the size of the population affected, the total value of the disruption could be substantial and potentially influence which mitigation option is selected.

The Value Tool for Natural Hazards has been updated with these values and a new version (v3.0) has been released.

Limitations

Despite our efforts to distribute the survey to a large number of people in York, the York sample was small (40 people total). This limits the capacity of the York estimates to reflect the real values that people associate with cultural heritage buildings, mental health and the uninterrupted supply of services and utilities in the area.

DEVELOPMENT OF THE ECONOMIC ANALYSIS SCREENING TOOL

Aim

To provide an economic analysis tool for the evaluation of the (tangible and intangible) costs and benefits of mitigation options that enables managers to evaluate and prioritise the treatment options that are likely to provide the best value for money.

Background

At the State and National levels, there is a need for simple and robust tools that help to prioritise treatment options for different natural hazards. Knowing the risk and the treatment options that are available to reduce that risk is only part of the picture. It is also very important to know how costly those treatment options are and, when they reduce the risk, what benefits they create.

Approach

We created a tool in the form of a macro enabled excel file that can link risk, treatment options and their potential effectiveness with economic data in a

simple and robust way. The Economic Analysis Screening Tool (EAST) provides a quick overview of the value for money that can be obtained from different mitigation options (when both the tangible and intangible costs and benefits of mitigation options are taken into account), and it improves the ability of managers to make a business case for natural hazard mitigation. With EAST, managers will be able to:

- conduct economic analyses in weeks rather than months or years,
- identify the options that are most worth developing business cases for,
- identify and prioritise the type and quantity of information that is needed to improve decisions and the confidence in those decisions,
- clarifying the counterfactual (business as usual or another baseline), and
- determine the importance of non-market values for different decisions.

Results

The development of EAST has been completed. The tool has been tested by a large number of end-users that have been using it as part of the course on how to use economics in natural hazards management. We have received abundant feedback on the tool, on how we can improve it and what end-users would like to see in it that is not there already. With this feedback we have been improving the tool. The final version of the tool, after all the feedback has been addressed, will be uploaded to the BNHCRC website, where it will be available for download.

Three important items will be available from the same BNHCRC website:

- The Economic Analysis Screening Tool (macro enabled excel file)
- Guidelines for the Economic Analysis Screening Tool
- A compilation of videos that show how to use the tool and demonstrate through different examples how to conduct a benefit-cost analysis of different mitigation options for different natural hazards.

Limitations

EAST is only a screening tool, so it is limited in what it can do and the information it can provide to users. EAST cannot be used to evaluate impacts of natural hazards on the wider economy (i.e. Gross Regional or National Domestic Product), different sectors of the economy or any other type of evaluation that is relevant to the macro scale. The tool does not estimate the opportunity costs of a given loss or revenue gains/losses for different industries. EAST cannot be used to estimate the impact of a hazard on communities in order to make political decisions and allocations of aid funds. The tool does not include inflows of money into the area affected, such as insurance payments, payments by government, recovery and restoration programs, aid funds or donations, and it does not incorporate potential economic benefits resulting from the hazard, such as an economic boost to the construction industry post-disaster.

Although EAST can be used to estimate the damage of a single hazard event and can provide estimates for cost-of-impact assessments, it is not the purpose of the tool. EAST should be used instead as an ex-ante analysis tool (rather than

a post-event analysis tool) for strategic decision making to help prioritise resource allocation between different mitigation options.

FREE ONLINE VIDEO COURSE ON THE ECONOMICS OF NATURAL HAZARDS

Aim

To provide a Free Online Video Course with training materials relating to the application of economics to the management of natural hazards. The target audience for the video course are natural hazard managers, decision makers, and researchers interested in the application of economics to the management of natural hazards. The video series can be accessed here.

Background

Despite substantial interest in economics within the emergency management sector, there is still a general lack of capacity in the sector to fully understand and to carry out economic analyses (Clayton et al. 2014). Managers have limited familiarity with economic evaluation methods and limited knowledge on how to use of the information derived from economic analyses. In addition, while hazard management agencies collect large amounts of information on their mitigation activities, their costs, their effectiveness, as well as natural hazard impacts, this information is generally not collected in a form that can be readily used in economic models. Agencies do not collect their data with strategic economic analyses in mind, and, because of this, there can be inconsistencies and holes that make the carrying out of economic analyses difficult. Increasing the economic capacity within the sector will help address these challenges. As one of our end-users pointed out:

> "A free online course focussed on emergency management economics, that allows for greater and more effective understanding and application of economic tools, can only benefit our stakeholders. The discipline of economics is poorly understood by the quite diverse emergency management community. A well designed course, utilising a well-recognised and proven platform, can only help. In addition, a free online course will add another useful tool to our emergency management toolbox, for use as required."
>
> **Mal Cronstedt**
> **Deputy Commissioner**
> **Strategy and Emergency Management Command**
> **Department of Fire and Emergency Services (DFES), WA**

The course will help natural hazard managers appreciate the importance and challenges associated with economic analyses when applied to the management of natural hazards and recognise the data requirements.

Approach

We created a free online course that provides natural hazard managers with easy-to-understand explanations of key economics concepts that are relevant

to natural hazard management. In this course, managers are exposed to the different economic analysis available and the data requirements for each type of analysis. Using drawings and simple examples, we explain how to use economic analysis to assess the value for money of different mitigation options, what users need to think about when conducting an economic analysis, and how to interpret the results.

Scripts for videos and associated materials were prepared. Videos with a green screen background were developed, and very simple hand drawings to explain each of the concepts presented were sketched.

A pilot video was sent to 40 end-users of 14 different organisations to check whether they liked the presentation style (hand drawings) or if they would prefer a PowerPoint presentation style for the videos. The feedback was very positive, they were very enthusiastic about the video series coming together, and they all liked the idea of using hand drawings to present the content (instead of using a PowerPoint presentation).

Some end-users suggested minor changes to the pilot video in order to make it easier for them to remember what they have learned (e.g. add sentence at the start to explain what they are going to learn + a summary at the end to highlight what they have learned). We modified the content of the videos to incorporate their feedback in the whole video series.

The BNHCRC communications team then took the raw material (videos with green screen background, videos with hand drawings, audio files and a storyboard for each video) to put it all together and produce the videos with a professional finish.

Results

We created a video series of 10 short videos that explain the application of economic principles to the evaluation and ranking of natural hazard mitigation options. The videos provide end-users with step-by-step explanations and empirical examples of how the benefits of mitigation options are calculated. At each stage of the process, we highlighted the data requirements. The videos are now available to all BNHCRC end-users and the public from the BNHCRC website and the BNHCRC YouTube channel.

Limitations

The videos only provide a very brief introduction to some of the most common economic principles used when evaluating the costs and benefits of natural hazards mitigation. Although a few numerical examples were presented to explain some of the more complex concepts, viewers would require a lot more practice and hands-on experience to fully understand some of the intricacies inherent in the application of economics to natural hazards.

TRAINING COURSE ON HOW TO USE ECONOMICS IN NATURAL HAZARDS MANAGEMENT

Aim

Upskill and build capacity within the emergency management sector so that natural hazard managers and practitioners feel more confident to both commission and use economic information to aid their decision making.

Background

The background to this course is similar to the free online video course presented above. Research (and partly our experience as well) has shown that despite substantial interest in economics, there is still a general lack of economic capacity within the natural hazards management sector (Clayton et al. 2014). Managers generally have limited familiarity with most economic evaluation methods or rarely know how to use of the information derived. By delivering training programs that build economic capacity within the sector, we hope to improve the use and usefulness of economic evaluation for natural hazard managers.

Approach

We asked 40 end-users of 14 different organisations to tell us about:

- The needs within their organisations in terms of economics? (i.e. the current level of knowledge or expertise in the use of economics for decision making within their organisation).
- Their preferred alternative if face-to-face workshops could not be delivered. Our end-users and the BNHCRC were initially interested in a 1-day course on the economics of natural hazards (using the tools we developed) delivered in different cities in Australia. However, due to Covid-19 restrictions, there was a high risk that travel would be limited or restricted and that the workshops might need to be cancelled and re-scheduled. We then asked our end-users their preferred alternative, and they suggested an online course in the form of short webinars delivered over several weeks.
- The relevance of the proposed course to them and/or others. We outlined the proposed course and asked them how relevant the course would be for their own work and to other people within their organisation.
- The format of the course delivery. We asked them if they thought webinars were a good medium, and how the webinars needed to be structured so that they would successfully achieve this type of training.

We took onboard the suggestions from our end-users in terms of duration for the webinars (1 to 1.5 hours for each session), the structure of the webinars (start simple and build on the material taught), and how hands-on the experience needed to be (explain things through exercises that they can do with us and provide homework). We developed the content for 3 out of 4 sessions with exercises to do during the sessions and homework exercises. We left the 4th (last) session open (i.e. topic to be decided), so that participants could select the topic

that they wanted to focus on in that session. We then developed the material for the 4th session after the participants selected the topic. We delivered the four sessions over four consecutive weeks for each group, each session one hour and a half long.

The BNHCRC communications team promoted the course, handled registrations, sent all information and material to participants, and hosted the webinars on Zoom. We capped participant numbers for each group at 20 people.

Results

Demand for the course was very high and registrations for the first two groups sold out within a week of opening registrations. We then opened registrations for another 2 groups. We delivered the course to 4 cohorts; in the end, approx. 60 people received the training. Feedback for the course has been excellent, with a large number of participants expressing their gratitude for the creation of the course, as reflected by this comment from one of our end-users:

> "Thanks Abbie and Veronique. I am blown away at the quality and professionalism of this course, how well it has been delivered and the sheer complexity of the tool you have developed and shared. […] Incredible work. Thank you so much for sharing."
>
> **Amanda Lamont**
> **Emergency Services Volunteer, Volunteer Firefighter,**
> **Emergency Management Advisor**
> **Australian Red Cross, Country Fire Authority**

Limitations

Although the course was a success and very well received by the end-users who participated in it, this does not necessarily mean that participants will use the knowledge gained in their work or that they will be able to influence decision-making within their organisations. We will contact the participants again in 6 months to ask about this and ascertain how much they have used the things they learned in the course.

Also, we only trained approx. 60 people. In the greater scheme of things, this is only a drop in the ocean of emergency management. In order to make a greater difference in how decisions are made for investments in mitigation and improve the general capacity in the sector to fully understand and to carry out economic analyses, a lot more people would need to be trained. Without additional training, the use of economic evaluation to support decision making in natural hazards management in Australia will remain limited.

UTILISATION AND IMPACT

SUMMARY

All our tools and products have now been completed and delivered. Our end-users have had a chance to view, use and comment on the different products delivered by the project. We have received very positive feedback for these products. We have outlined below, the extend of use, the utilisation potential and the utilisation impact for each of the utilisation products of our project (i.e. all outcomes except the non-market valuation study, which was conducted with the purpose of updating the Value Tool).

VALUE TOOL ONLINE SEARCHABLE DATABASE

Output description

The Value Tool for Natural Hazards is a database containing the most relevant data on intangible (non-market) values for the assessment of natural hazards impacts in Australia. The Value Tool is available as an online searchable database (available from the BNHCRC website) and in the form of a spreadsheet with filters. In both versions, the values are separated by category (i.e. health, environmental, and social values).

The spreadsheet version of the Value Tool has been updated with the results of our non-market valuation study estimating the values of cultural heritage, social disruption and mental health in the context of earthquake mitigation in the Shire of York, WA. These values (cultural heritage, social disruption and mental health) were identified as major gaps in the literature and there was previously little to no data on these values in the Value Tool. Our study addressed this gap in research and improved the data available to end-users in the Value Tool.

Extent of use

- End-users of the BNHCRC and external organisations working in the natural hazards space are now able to access the best available data on intangible (non-market) values relevant to natural hazards from the online searchable database and from the spreadsheet (which can be downloaded from the BNHCRC website).
- More than 80 end-users have received a copy of the Value Tool and most of them have learned to use it in the course we conducted on how to use economics in natural hazards management.
- The online Value Tool and the accompanying Guidelines allow users to integrate non-market values into their economic analyses without having to conduct original non-market valuation studies – which tend to be labour intensive and expensive, and usually require several months or years to be completed. The Guidelines guide users through a step-by-step process to help them select the appropriate non-market values, adjust them to their particular context and easily integrate them in economic analyses of natural hazard mitigation.

- Data available in the online searchable database can be used for the natural hazard specified (some values are useful for several hazards, some are useful for only one hazard), although the way they are used and adapted to the problem at hand may vary between hazards.

Utilisation potential

- By providing accessible and credible information on the dollar value of intangible (non-market) values that are impacted by natural hazard events and mitigation actions, managers will be more likely to include them in their analysis.
- The Value Tool, its accompanying Guidelines and the online searchable database version of the Value Tool make it easier for decision makers to access credible information on the values of intangibles to include in benefit-cost analysis of mitigation activities. This will increase the accuracy of the estimated impacts and benefit-cost ratios outputs obtained from economic analyses.
- The environmental values available in the online database can be integrated in other BNHCRC tools, such as the University of Adelaide's UNHaRMED. This will improve the outputs from the spatial decision support system (DSS) by allowing the comparison between tangible and intangible impacts.

Utilisation impact

- We used the Value Tool and explained how to use it in the course on how to use economics in natural hazards management. The participants of the course now have immediate access to a non-market values database, and have been shown how to conduct a benefit transfer and how to integrate non-market values in economic analyses.
- Throughout the development of the Value Tool we have presented the tool and explained why it is important to include non-market values in economic analyses of natural hazards mitigation. This engagement has increased awareness about non-market values (intangibles), the methods we use to assign a dollar values to them, and the challenges we face when integrating non-market values in economic analyses.
- Increased awareness of non-market values and their importance has resulted in better acceptance of non-market values in the emergency management sector (e.g. the WA Department of Planning, Lands and Heritage, the SA Department for Environment and Water, the WA Department of Fire and Emergency Services, University of Adelaide, and GeoScience Australia have requested we help them include non-market values in their work and their analyses). Today, many end-users of the BNHCRC know what non-market values are and understand why it is important to include them (in dollar values) in economic analyses.
- Increased awareness of non-market values and their importance has also led to an increase in demand for studies and tools that allow end-users to integrate non-market values more easily in their analyses.

- End-users that have directly used the Value Tool, or that have requested we help them include non-market values in their analyses, have been able to see the trade-offs between tangible and intangible impacts more clearly. With these trade-offs more clearly elucidated, managers are able to make decisions based on a more comprehensive assessment of the effects of different mitigation options.

Utilisation and impact evidence

1 Maqsood T, Wehner M, Mohanty I, Corby N, Edwards M, Gibson F and Rogers A. *Launceston flood risk mitigation assessment project - suburb of Newstead*. Report prepared by the Community Safety Branch, GeoScience Australia and the Centre for Environmental Economics and Policy for the BNHCRC, the Tasmanian Department of Premier and Cabinet, the Tasmanian State Emergency Service, the Launceston City Council (LCC), the Launceston Flood Authority and the Northern Midlands Council, 16 August 2017.

2 Rogers A, Dempster F, Hawkins J, Johnston R, Boxall P, Rolfe J, Kragt M, Burton M, Pannell D. *Valuing non-market economic impacts from natural hazards: A review*. Natural Hazards 2019; 99:1131–1161.

3 Florec V, Rogers A. *Tools that help decision making in natural hazard mitigation*. Paper presented at the AFAC - BNHCRC conference in Melbourne, 28-30 August 2019.

4 Rogers A, Florec V. *Filling the gaps: How economics can help make important decisions when information is missing*. Paper presented at the AFAC - BNHCRC conference in Perth, 5-7 September 2018.

5 Rogers A, Gibson F, Florec V, Hailu A, Pannell D. *Including the intangible benefits of bushfire mitigation in economic analyses: A 'Value Tool' for informed decision making*. Paper presented at the AFAC - BNHCRC conference in Sydney, 4-7 September 2017.

6 Gibson F, Rogers A, Florec V, Hailu A, Pannell D. *Appreciating the whole picture: including Intangible values in decision making*. Poster presented at the AFAC - BNHCRC conference in Sydney, 4-7 September 2017.

ECONOMIC ANALYSIS SCREENING TOOL

Output description

The Economic Analysis Screening Tool (EAST) is an economic analysis tool for the evaluation of the (tangible and intangible) costs and benefits of mitigation options. The tool integrates information on the risk and potential impacts from natural hazards, the mitigation options available to reduce the risk associated with, or exposure to, natural hazards, the costs of mitigation options, and the potential benefits they could generate. EAST integrates all this information in order to provide a quick and rough overview of the value for money managers can get from investing in different mitigation options.

Extent of use

- We sent the draft (Beta) version of EAST to a small (10) number of end-users to give us feedback on:
    - Does everything work (buttons, dialogue boxes, etc.) as expected? At this stage, we needed to make sure that the tool worked well, that all buttons worked, and that nothing was breaking or freezing.
    - We asked our end-users if they understood what data was required in the Parameters sheet, in the Effect Mitigation sheet, and in the Values sheet.
    - We asked our end-users about the look of the tool (i.e. aesthetics), how easy it was to use, and what they would have liked to have seen in the tool that wasn't there.
    - We used their feedback to correct typos, improve some of the aesthetics and add information icons to each section with explanations on the data requirements.
- We used EAST as a training tool to explain key economic principles to 4 groups of end-users (groups of 15 to 20 people each) in the course on how to use economics in natural hazards management. End-users had a hands-on experience of EAST while attending the sessions and while doing their homework.
- EAST was used to conduct a case study of bushfire management through prescribed burning in the south-west of WA. The results of this case study were compared with the results of an in-depth economic analysis of prescribed burning in the same area, which was conducted in recent years and took several years to be completed. We found that, despite a few differences, the results from EAST were comparable to those from the in-depth analysis and provided enough information to understand the value for money that each prescribed burning strategy generates. The findings from this case study using EAST (previously known as the Quick Economic Analysis Tool, or QEAT) were published in a peer-reviewed article in the Australian Journal of Emergency Management (see publications section in this report).
- The case study was useful to validate the tool. It showed the potential for EAST to be used as an economic screening tool that allows natural hazard managers to rapidly identify the best mitigation options and prioritise the information that is needed to improve their decisions and/or their confidence in those decisions.
- EAST, its Guidelines and a series of videos explaining how to use it will be available from the BNHCRC website later this year.

Utilisation potential

- EAST can help managers identify the options that are most worth developing business cases for and those that deserve little consideration.
- The results obtained from EAST and the sensitivity analysis can help managers identify and prioritise the type and quantity of information that

they need to improve their decisions and the confidence they have in those decisions.

- When using EAST, users need to be very clear about the baseline (i.e. the counterfactual that they are comparing things to), whether it is a doing-nothing scenario, or business as usual or some other baseline. In doing so, the process of using EAST can help managers and practitioners develop their economics thinking. EAST will help improve the economic capacity within the emergency management sector.
- With the use of EAST, emergency management organisations will have the capacity to reduce the time and effort spent in evaluating different mitigation options. Since EAST provides a quick and rough idea of the value for money that can be obtain from different options, managers can focus their time and resources on collecting the additional data that will increase the confidence in their decisions.

Utilisation impact

- We have sent EAST to many end-users and have also used it as a training tool in the course on how to use economics in natural hazards management. The managers and practitioners that participated in the course, have a better understanding of economic principles and are better equipped to interpret the results of an economic analysis. With the course and the use of EAST, we have increased the economic capacity of the sector.
- The results from EAST allow managers to get a quick idea of the most effective mitigation option(s) and how to efficiently allocate resources for mitigation. When the results are robust enough and the preferred mitigation option(s) is easily recognizable, there might not be a need to conduct further analyses and decisions may be made based on the results from EAST. In such cases, EAST may significantly reduce the time necessary to make decisions and save the time, effort and resources that would otherwise be used to conduct more lengthy, in-depth analyses.
- We have also presented EAST and its potential to our end-users at conferences and forums. This engagement has increased awareness about the tool and its potential.

Utilisation and impact evidence

1 Florec V, Rogers A. *Economic analysis of natural hazard mitigation using the Quick Economic Analysis Tool*. Australian Journal of Emergency Management 2020; Vol 35 (4), October 2020, pp. 48-55.

2 Florec V, Rogers A, Hailu A, Pannell D. *Quick economics: tools that help decision making in natural hazard mitigation*. Poster presented at the AFAC - BNHCRC conference in Melbourne, 28-30 August 2019.

3 Florec V, Rogers A. *Tools that help decision making in natural hazard mitigation*. Paper presented at the AFAC - BNHCRC conference in Melbourne, 28-30 August 2019.

FREE ONLINE VIDEO COURSE ON THE ECONOMICS OF NATURAL HAZARDS

Output description

The video course is a series of 10 short videos that explain the application of economic principles to the evaluation and ranking of natural hazard mitigation options.

Extent of use

- The entire video series is available to all BNHCRC end-users and the public from the BNHCRC website and the BNHCRC YouTube channel.
- The videos have been widely promoted, via the BNHCRC newsletter and the course on how to use economics in natural hazards management. They have so far had between 22 and 128 views.
- Before the release of the series, a pilot video was sent to 40 end-users of 14 different organisations to check if they liked the presentation style (hand drawings) and ask how useful they found the information imparted in the video.
- The feedback from our end-users indicated that they were very happy about a video series like this one being created and are also happy with the format of the drawings (instead of a PowerPoint presentation style).
- Some end-users suggested minor changes to the videos in order to make it easier for them to remember what they learned (e.g. add a sentence at the start of each video explaining what they are going to learn and a summary of what they learned at the end of each video). This feedback has been integrated in the videos: the scripts were edited to incorporate their suggestions, and additional filming was done for each video.

Utilisation potential

- The Free Online Course helps natural hazard managers build their skills and understanding in the core economics concepts and models that are relevant to natural hazard management.
- The information explained in the course can help natural hazard managers become enthusiastic and effective utilisers of economic analysis.
- The comments received so far from our end-users show that they are very happy about the creation of the free online course.

Utilisation impact

- The course is helping to build economics capacity within the emergency management sector. with this course, practitioners learn how to appropriately interpret and use the results of economic analyses, understand the importance and challenges associated with intangible values, and understand more broadly the data requirements for particular types of economic analyses.

- End-users that watch all the videos from the course will improved their ability to frame decision-making problems appropriately and choose the appropriate economic tools to define and compare options.
- End-users that complete the course will be able to understand data requirements for economic analyses and may create a shift in thinking within their agency regarding data collection, to ensure that the data collected are useful for economic analyses and management decisions.

Utilisation and impact evidence

1 See comments from end-users in the PRODUCT USER TESTIMONIALS section above.

2 Florec V, Rogers A, Hailu A, Pannell D. *Economics 101 for the emergency management sector*. Poster prepared for the BNHCRC, initially planned for the AFAC – BNHCRC conference in Adelaide, 25-29 August 2020 [conference now cancelled].

3 The video series is available from the BNHCRC website and the BNHCRC YouTube channel.

TRAINING COURSE ON HOW TO USE ECONOMICS IN NATURAL HAZARDS MANAGEMENT

Output description

This training course is a series of 4 webinars of 1 and a half hours each, where we explain how to conduct an economic evaluation of different mitigation options for natural hazards. In this course, we used the Economic Analysis Screening Tool as a training tool. The course was structured as a series of hands-on exercises to do during the sessions plus additional exercises to be done as homework. The course progressed through increasingly complex concepts, and we designed the exercises in a way that each one of them build-on the knowledge gained in the previous ones.

Extent of use

- We had planned to originally deliver the course to 3 cohorts (of 20 people each), but the demand for the course was very high and registrations for the first two groups sold out within a week of opening registrations. We then opened registrations for the 3rd group and decided to run an additional (extra-contractual) course for a 4th group. We have delivered the course to 3 cohorts so far, the 4th one is being delivered at the time of writing this report.
- In total, at least 50 people have completed the course and attended all sessions. By the end of the course, the participants have a much better understanding of the data requirements for economic analyses, and they know how to estimate the benefits of mitigation options, how to interpret the results of a benefit-cost analysis, how to conduct a one-at-a-time sensitivity analysis, and how to use the information obtained from the sensitivity analysis.

Utilisation potential

This course has considerable utilisation potential. In a way, the course does not end after the 4 cohorts have been trained. We have recorded all the sessions and with the BNHCRC communications team, we are going to create a series of videos with the highlights from the course. These videos will then be available in the BNHCRC website, so that anyone that wants to go through the whole course, can do it on their own. All questions asked by the participants will be converted to text (to protect the privacy of the participants) and the answers from the facilitators (Dr Veronique Florec and Dr Abbie Rogers) will be available in the video compilation. The exercises and homework will also be available, so anyone interested can go through the whole material of the course. With all the material available online to the public, the utilisation potential of the course is immense.

Utilisation impact

- With this course, we have built economic capacity within the emergency management sector.
- After participating in the course, people feel empowered and better equipped to conduct economic analyses. They see possibilities for better mitigation of natural hazards through the use of the knowledge they have gained.
- Participants have a much better appreciation of the importance of, and the challenges associated with, non-market values.
- Participants enjoyed the course and found a new (or renewed) interest in economics.

Utilisation and impact evidence

The course has had great success and some end-users want to see the course delivered to other sectors in order to build economic capacity in those sectors. For instance, members of the electricity distribution industry have asked if the course can be delivered to a group of people that work in natural hazard management within the networks. We are currently discussing this possibility with them.

The feedback for the course has been remarkably positive. Some of the feedback from course participants appears below:

> "I found the course to be excellent – well run, useful and informative. This has been fantastic. I'm a newbie to economics and it has been very worthwhile. I can see many practicalities for implementing it."
>
> **Peta Turner**
> **Program Leader Capability and Resilience**
> **Risk, Capability and Analysis**
> **WA Department of Fire and Emergency Services**

> "Thank you so much for allowing and providing such an empowering course for me. The possibilities for better mitigation through this tool

are essential for attracting investment now and in the future. This knowledge will empower a logical and undeniable calculation of positive outcome mitigation investment."

Greg Cook
Senior Risk Consultant
Emergency Management Program
LGIS

"Thanks Abbie and Veronique. I am blown away at the quality and professionalism of this course, how well it has been delivered and the sheer complexity of the tool you have developed and shared. I am keen to review all we have discussed and think of the translation into words of the numbers, to be able to tell the story. Incredible work. Thank you so much for sharing. I have a degree in Economics - but it was never this much fun back at Uni! Research utilisation at its best"

Amanda Lamont
Emergency Services Volunteer, Volunteer Firefighter, Emergency Management Advisor
Australian Red Cross, Country Fire Authority

"I support Amanda's comments. Very well structured course."

Belinda Skilton
Technical Advisor
SA Department for Environment and Water

"I also agree with Amanda, a very informative and professionally provided course. Thank you Abbie and Vero"

Ian Colquhoun
SA Department for Environment and Water

"Great course Vero and Abbie. Many thanks for your efforts."

Martin Wehner
Structural engineer
Geoscience Australia

"Great work... Huge credit to Both Veronique and Abbie... I enjoyed to course. I am hoping to use this knowledge to extend for wind damage."

Geeth Bodhinayake
Research Engineer
Cyclone Testing Station

PUBLICATIONS LIST

PEER REVIEWED JOURNAL ARTICLES

1 Rogers A, Dempster F, Hawkins J, Johnston R, Boxall P, Rolfe J, Kragt M, Burton M, Pannell D. *Valuing non-market economic impacts from natural hazards: A review*. Natural Hazards 2019; 99:1131–1161. Available here.
2 Florec V, Rogers A. *Economic analysis of natural hazard mitigation using the Quick Economic Analysis Tool*. Australian Journal of Emergency Management 2020; Vol 35 (4), October 2020, pp. 48-55. Available here.
3 Florec V, Burton MP, Pannell DJ, Kelso J, Milne G. *Where to prescribed burn: the costs and benefits of prescribed burning close to houses*. International Journal of Wildland Fire 2020; 29:440-458. Available here.
4 Florec V, Thompson MP, Rodriguez y Silva F. *Cost of suppression*. In Manzello, S.L. (eds) *Encyclopaedia of Wildfires and Wildland-Urban Interface (WUI) Fires*, Springer International, Basel, Switzerland 2020. Edited book available here.

CONFERENCE PAPERS

1 Florec V, Rogers A. *Tools that help decision making in natural hazard mitigation*. Paper presented at the AFAC - BNHCRC conference in Melbourne, 28-30 August 2019.
2 Rogers A, Florec V. *Filling the gaps: How economics can help make important decisions when information is missing*. Paper presented at the AFAC - BNHCRC conference in Perth, 5-7 September 2018.
3 Rogers A, Gibson F, Florec V, Hailu A, Pannell D. *Including the intangible benefits of bushfire mitigation in economic analyses: A 'Value Tool' for informed decision making*. Paper presented at the AFAC - BNHCRC conference in Sydney, 4-7 September 2017.
4 Florec, V. and Milne, G. (2019) "Evaluating the Effectiveness and the Economic Benefits of Fuel Management in the Wildland Urban Interface using Wildfire Simulation." Peer-reviewed research proceedings of the 6th Fire Behaviour and Fuels Conference: Fuels of Today - Fire Behaviour of Tomorrow, 29 April – 3 May 2019, Albuquerque (New Mexico, US), Sydney (NSW, Australia) and Marseille (France). Available here.
5 Pannell D. *Economics of bushfire risk mitigation*. Paper presented at the Australasian Agricultural & Resource Economics Society's conference in Perth, 11-14 February 2020.
6 Florec V, Burton M, Pannell D, Kelso J, Milne G. *Where to prescribed burn: the costs and benefits of prescribed burning close to houses*. Paper presented at the Prescribed burning conference in Perth, 31 Jul - 1 Aug 2019.
7 Florec V. *The costs and benefits of bushfire mitigation : integrating intangible (non-market) values in decision making*. Paper presented at the France and Australia Bushfire Science Workshop, online 15-17 September 2020.
8 Florec V. *The costs and benefits of prescribed burning in the south-west of Western Australia*. Paper presented at the Australasian Agricultural & Resource Economics Society's conference in Brisbane, 7-10 February 2017.

TECHNICAL REPORTS

1 Maqsood T, Wehner M, Mohanty I, Corby N, Edwards M, Gibson F and Rogers A. *Launceston flood risk mitigation assessment project - suburb of Newstead*. Report prepared by the Community Safety Branch, GeoScience Australia and the Centre for Environmental Economics and Policy for the BNHCRC, the Tasmanian Department of Premier and Cabinet, the Tasmanian State Emergency Service, the Launceston City Council (LCC), the Launceston Flood Authority and the Northern Midlands Council, 16 August 2017.
2 Rogers, A.A., Gibson, F.L., Boxall, P.C., Burton, M.P., Hawkins, J.I., Johnston, R.J., Kragt, M.E., Rolfe, J. and Pannell, D.J. 2018. Value Tool for Natural Hazards: Guidelines. Bushfire and Natural Hazards CRC Report 361, The University of Western Australia, Crawley.
3 Rogers, A.A., Rollins, C., Florec, V. 2021. Willingness to pay to avoid the non-market impacts of earthquakes in York, Western Australia. Bushfire and Natural Hazards CRC Report 667, The University of Western Australia, Crawley.
4 Florec, V., Rogers, A.A. and Pannell D.J. 2021 Economic Analysis Screening Tool: Guidelines. Bushfire and Natural Hazards CRC Report 665, The University of Western Australia, Crawley.

OTHER

1 Gibson F, Rogers A, Florec V, Hailu A, Pannell D. *Appreciating the whole picture: including Intangible values in decision making*. Poster presented at the AFAC - BNHCRC conference in Sydney, 4-7 September 2017.
2 Florec V, Rogers A, Hailu A, Pannell D. *Quick economics: tools that help decision making in natural hazard*

mitigation. Poster presented at the AFAC - BNHCRC conference in Melbourne, 28-30 August 2019.

3 Florec V, Rogers A, Hailu A, Pannell D. *Economics 101 for the emergency management sector*. Poster prepared for the BNHCRC, initially planned for the AFAC – BNHCRC conference in Adelaide, 25-29 August 2020 [conference cancelled].

4 The entire video series of the free online course on the Economics of Natural Hazards is available from the BNHCRC website and the BNHCRC YouTube channel.

5 The searchable online database version of the Value Tool is available here. The Excel spreadsheet version is available here, and the Guidelines are available here.

6 The Economic Analysis Screening Tool (EAST) and its guidelines are currently available to end-users upon request. Later this year, they will be both available for download from the BNHCRC website.

7 Project newsletters. We sent an annual newsletter to our end-users (generally around 40 end-users) with information on our project, what we had been up to and what tools we had created or what articles we had published that could be useful to them. We sent a total of 4 newsletters in March 2018, January 2019, February 2020, and May 2021.

8 Pannell D, Florec V and Gibson F. *Economics of Bushfire-Risk Mitigation*. Poster presented at the Australasian Agricultural & Resource Economics Society's conference in Perth, 11-14 February 2020.

9 Rogers A, Gibson F and Florec V. *Demonstrating the use of a 'value tool' for natural hazard decision making: how to include intangible benefits in economic analyses*. Workshop delivered at the 10th Australasian Natural Hazards Management Conference, Perth 31 Oct – 1 Nov 2017.

10 Florec V and Pannell D. *Economic assessment of bushfire risk management options in western Australia*. Poster presented at the 10th Australasian Natural Hazards Management Conference, Perth 31 Oct – 1 Nov 2017.

11 Florec V and Pannell D. *Economic evaluation of bushfire management options in Western Australia*. Presentation delivered to the Risk Subcommittee of the WA Department of Fire and Emergency Services, Perth, on 1st Mar 2017, and to the Risk and Capability branch of the same Department on 20th April 2017.

12 Florec V. Economics of natural hazards: Helping decision-making when data is missing. Presentation delivered to the Bureau of Meteorology, Perth, on 28th May 2018.

TEAM MEMBERS

Our team is a group of experienced environmental economists. We have extensive experience in conducting multidisciplinary research projects in a variety of topics, including natural hazards, water, land, the marine environment, biodiversity, and climate. We collaborate with researchers from around the world. We have developed a large number of tools that include optimisation, statistics, social surveys, benefit:cost analysis, project evaluation, bio-economic models, non-market valuation, and decision support tools. We integrate information from physical sciences, biology, and social sciences within our economic frameworks.

RESEARCH TEAM

Veronique Florec (project leader)

BA(Econ) Grenoble, France; BA(Econ) Sussex, United Kingdom; MA(Econ) Paris, France; PhD Western Australia, Australia.

After living and studying in Colombia and France, Veronique came to Australia to travel and fell in love with the country. She completed a PhD on Environmental and Resource Economics at The University of Western Australia in 2016, investigating the economics of bushfire management in the south-west of Western Australia. Since completing her PhD, Veronique has worked at the Centre for Environmental Economics and Policy at UWA.

Her research focuses on evaluating value for money for investments in natural hazards management. It integrates socio-economic information and technical information about hazard risk, hazard severity and the effectiveness of management options in order to optimise the allocation of available resources for hazard mitigation.

Abbie Rogers

BSc; PhD Western Australia, Australia.

Having always respected the environment but recognising that there are limited resources available to manage it, lead me on a path to study a BSc in Natural Resource Management, followed by a PhD in Environmental Economics at The University of Western Australia. Since completing my PhD in 2011, I have worked in the School of Agriculture and Environment and the Centre for Environmental Economics and Policy at UWA, currently as an Assistant Professor in Research.

My primary research interests are in the application of non-market valuation to estimate community values and preferences for environmental conservation and management. This includes applications in the context of marine, terrestrial, and aquatic environments. Ultimately, I am interested in improving the application, understanding and accessibility of non-market valuation techniques such that they can be used to improve environmental decision making.

David Pannell

BSc (Agric); Bec; PhD Western Australia, Australia.

David Pannell is Professor of Agricultural and Resource Economics at the University of Western Australia, and Director of the Centre for Environmental Economics and Policy. He was an ARC Federation Fellow, 2007-2012. He has been a prominent commentator on environmental policy within Australia, arguing for policies that better reflect scientific, economic, and social realities. He was President of the Australian Agricultural and Resource Economics Society in 2000, a member of the WA Government's Salinity Taskforce in 2001, and a director on the Board of Land and Water Australia 2002-05.

His research includes the economics of environmental conservation; environmental policy; farmer adoption of land conservation practices; risk management; and economics of farming systems. His research has been published in seven books and 200 journal articles and book chapters, and has been recognised with awards from the USA, Australia, Canada, and the UK, including the 2009 ARC Eureka Prize for Interdisciplinary Research.

END-USERS

We regularly engage with our end-users to seek their feedback on our work and the tools we have developed, as well as to keep them up to date with our progress. Every year we send to our end-users a Project Progress Report that provides them with details of what we have been up to and links to access our publications, reports, and tools available where appropriate.

End-user organisation	End-user representative	Extent of engagement (Describe type of engagement)
SA Department for Environment and Water	Ed Pikusa	Lead end-user representative. Receives all our quarterly reports and annual reports and comments on them. Receives all our Project Progress Report and is consulted for feedback on

End-user organisation	End-user representative	Extent of engagement (Describe type of engagement)
		the products and tools we develop.
Office of Bushfire Risk Management, WA Department of Fire and Emergency Services	Tim McNaught	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Office of Bushfire Risk Management, WA Department of Fire and Emergency Services	Glen Daniel	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Office of Bushfire Risk Management, WA Department of Fire and Emergency Services	Paul Simpson	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Rural Bushfire Service, WA Department of Fire and Emergency Services	Murray Carter	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Fire and Emergency Services	Andrew Sanders	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Fire and Emergency Services	Malcolm Cronstedt	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Fire and Emergency Services	Victoria Chuter	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Fire and Emergency Services	Suellen Flint	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Fire and Emergency Services	Rachel Armstrong	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Bushfires NT	Mark Gardener	Receives our Project Progress Report and is consulted for

End-user organisation	End-user representative	Extent of engagement (Describe type of engagement)
		feedback on the products and tools we develop.
WA Department of Biodiversity, Conservation and Attractions	Lachie McCaw	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Biodiversity, Conservation and Attractions	Megan Porter	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Biodiversity, Conservation and Attractions	Katie MacWilliams	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
WA Department of Biodiversity, Conservation and Attractions	Murray Mitchell	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
SA Department for Environment and Water	Tim Groves	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
SA Department for Environment and Water	Mike Wouters	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Parks and Conservation Science; Environment, Planning and Sustainable Development Directorate ACT	Adam Leavesley	Adam has provided guidance and insightful suggestions for improving the free online video course on the economics of natural hazards. He has experience as a science communicator and with his feedback the course will be improved substantially. Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Rural Fire Service NSW	Simon Heemstra	Receives our Project Progress Report and is consulted for

End-user organisation	End-user representative	Extent of engagement (Describe type of engagement)
		feedback on the products and tools we develop.
SA State Emergency Service	Liz Connell	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Essential Energy	Ian Fitzpatrick	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Powercor	Dene Ward	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
United Energy	David Wilkinson	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Tas Networks	Michael Emmett	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Powerlink	Stephen Martin	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.
Western Power	Amir Sherkat Masoum	Receives our Project Progress Report and is consulted for feedback on the products and tools we develop.

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