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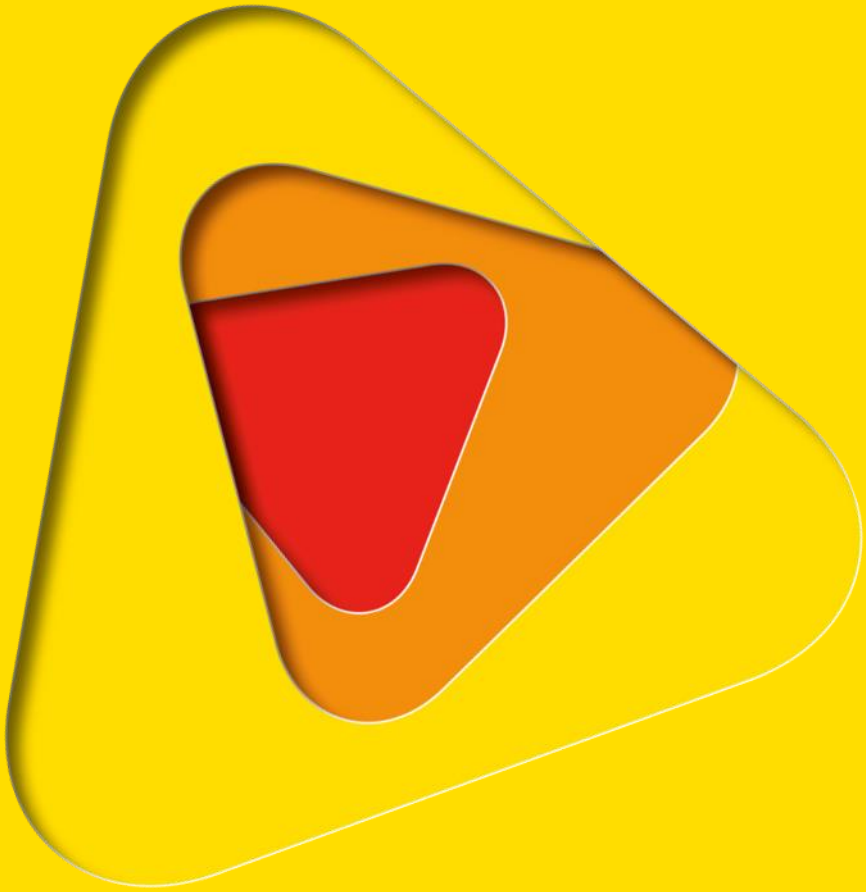
NATURAL HAZARD MITIGATION DECISION SUPPORT SYSTEM

Jeff Newman, Holger Maier, Hedwig van Delden, Aaron Zecchin and Graeme Dandy
The University of Adelaide
Bushfire and Natural Hazards CRC

Annual Report 2014



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NATURAL HAZARD MITIGATION DECISION SUPPORT SYSTEM 2014 ANNUAL REPORT

JULY 2014

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School of Civil, Environmental and Mining Engineering, The University of Adelaide, SA

An Australian Government Initiative

CRC AUSTRALIA

1. OVERVIEW

1.1. DISASTER LOSSES ARE SIGNIFICANT, AND CAN BE REDUCED

The impacts from natural disasters are staggering in regard to human and economic losses. While the immediate and post-crisis response to disasters is extremely important, mitigation activities before a natural disaster occurs can be extremely effective in reducing potential losses — for every dollar spent on mitigation, a saving of one and a half to five dollars in recovery costs can be expected (Rose, Porter et al. 2007). However, developing and implementing mitigation can be extremely difficult in practice, because of the difficulty of convincing decision makers of the advantages of spending money on mitigation works compared with the short-term benefits offered by other potential projects and activities. In addition, because disasters are relatively infrequent, the people influencing mitigation activities may have little personal experiences to guide their evaluation of risk, or the relative benefits of alternative mitigation options. Furthermore, mitigation budgets are generally limited, and given the difficulties mentioned above, the selection of an optimal set of mitigation options is very difficult when many alternative mitigation options are available.

1.2. HOW DECISION SUPPORT SYSTEMS HELP SOLVE THE PROBLEM

Because of these difficulties, the use of decision support systems (DSS) is advantageous, as such systems (1) are transparent and can quantify the expected benefits of mitigation investiture across multiple criteria, enabling strong arguments for the selection of particular mitigation options to be made, (2) can be used to assess the likelihood and consequences of natural disasters across multiple criteria, enabling less bias when assessing the relative benefits of mitigation options, and (3) can make use of formal optimization techniques to find optimal or near-optimal portfolios of mitigation options. However, DSSs for natural disaster mitigation have tended to focus on disaster preparedness and the immediate and post-crisis response to emergencies. Of those DSSs that have focused on mitigation, none have considered, simultaneously, both (1) temporal non-stationarity in climate or land use, and (2) the use of optimization to identify suitable mitigation portfolios. These two aspects are important, as natural disasters are likely to become more frequent with climate change, and because consequences of natural disasters are strongly sensitive to the land uses at the location of the natural disaster.

1.3. OUR APPROACH TO BUILDING DECISION SUPPORT SYSTEMS

Consequently, this project will develop an integrated natural hazard mitigation DSS framework, which will be used to develop prototype DDSs for three case studies. Of these three case studies, the first will consider the Greater Adelaide region, and the second will likely consider the entire Victorian state. Through a workshop driven development cycle, this project will deliver prototype DSSs to end users, that will optimize the choice of mitigation options, through assessing the performance of various options over the long term using simulation-optimisation approaches. The performance of mitigation options will be evaluated in an integrated way, across a number of natural hazards (bushfire, flooding, coastal surge and storm events) whilst taking account of land use and climate change.

Rose, A., K. Porter, N. Dash, J. Bouabid, C. Huyck, J. Whitehead, D. Shaw, R. Eguchi, C. Taylor, T. McLane, L. T. Tobin, P. T. Ganderton, D. Godschalk, A. S. Kiremidjian, K. Tierney and C. T. West (2007). "Benefit-cost analysis of FEMA hazard mitigation grants." Natural Hazards Review **8**(4): 97-111.

2. INTRODUCTION

Disaster mitigation planning is characterised by the need to make decisions in an increasingly complex environment. This complexity comes in a number of forms, including (i) the need to make decisions by selecting from a very large number of options, making it difficult to know which is best, (ii) the need to consider multiple, often competing, objectives during decision-making processes to account for a range of social, economic and environmental criteria, (iii) a lack of clearly-defined, measurable criteria with which to assess the utility of decisions, and (iv) uncertainty in future conditions, data and information.

At the same time, community expectation in relation to the level of protection that can be provided against disasters is increasing. Consequently, there is increased scrutiny of the decisions made in relation to disaster mitigation, necessitating increased transparency in the decision-making process and wise use of limited resources.

However, decision-support tools that enable the above goals to be achieved do not exist at present. Consequently, there is a need to develop a decision support framework that (i) is able to deal with complex problems in a systematic and transparent manner, (ii) makes best use of available sources of data and information, (iii) is adaptable/flexible, (iv) deals with multiple, competing objectives, (v) identifies mitigation options that represent the best possible (optimal) trade-offs between objectives, (vi) deals with uncertainty, (vii) caters to a large number of potential solutions, (viii) enhances understanding of the side effects and impacts of different combinations of policy options and (ix) adopts an interdisciplinary approach across various policy fields.

3. THE PROJECT

The project will develop user-friendly, computer-based prototype decision support tools that can assess the impact of different policy and planning disaster mitigation options on various economic, environmental and/or social objectives for three end-user defined case studies. This will enable the best possible disaster mitigation options to be identified, thereby increasing disaster preparedness, as well as reducing disaster impact and the cost of disaster response and rehabilitation. Consequently, the specific objectives of the project are:

1. To develop a systematic and transparent approach to sifting through, evaluating and ranking disaster and natural hazard mitigation options using analytical processes and tools.
2. To develop prototype decision support software tools that implement the above approach for three end-user defined case studies.

3.1. PROJECT OUTCOMES

The project outcomes will be:

1. Utilisation of a systematic and transparent approach to evaluating disaster and natural hazard mitigation options (e.g. infrastructure, land use, policy).
2. The ability to make more strategic and less responsive decisions in relation to mitigating the impact of disasters and natural hazards as a result of the availability of better information.

3. The availability of prototype decision support software tools for three end-user defined case studies to enable recommended options to be identified by sifting through and evaluating and ranking a large number of options.

3.2. RESEARCH QUESTIONS

Methodological questions the project will help answer, include:

1. What tools are helpful for elucidating mitigation options from domain knowledge experts in workshops (e.g. the use of system diagrams)?
2. How can we compare all mitigation options available, and identify the mitigation options that give the best possible trade-offs between objectives?
3. How might optimisation routines and hazard models be designed to reduce the computation time of finding mitigation options that represent near optimal trade-offs between decision objectives?
4. How significant is the inclusion of landuse change when assessing long term mitigation investment strategies in the three case studies?
5. How can uncertainty be better incorporated within natural hazard mitigation assessment?
6. How can metrics be improved for automated landuse model calibration?

Questions, relating to the case studies, that the project will help answer, include:

(1) For each case study, what are the optimal mitigation options across long-term planning horizons?
(2) For each case study, how will climate and land use change affect natural hazard risk, and what are the implications for this in regard to disaster mitigation budgets?
(3) For each case study, what trade-offs exist between economic, environmental and/or social objectives for different mitigation options?

4. WHAT'S BEEN HAPPENING?

4.1. CASE STUDIES

Work has commenced on the Greater Adelaide case study:

1. An initial case study workshop was conducted on November 2013 with the South Australian Fire and Emergency Services Commission. The state of South Australian mitigation assessment was discussed, and a problem formulation developed for use in the DSS.
2. Data, as listed in Appendix A, have been obtained for developing the land use change model.
3. Work has also commenced on developing a mock-up interface for the DSS for this case study.
4. Code is being developed for integrating optimization with the Metronamica modelling platform.
5. The first workshop for this case study has been organised for the 18th of September, with the program and participants invited given in Appendix B. Ethics approval has been submitted to the University of Adelaide's ethics committee to conduct this workshop.

4.2. RECRUITING

Jeffrey Newman was taken on as a postdoctoral research fellow for the project. He brings research experience in modelling and optimization to the team, and will help coordinate the project activities.

Graeme Riddell and Charles Newland have been recruited as PhD students associated with the project. Graeme's PhD project will focus on the incorporation of uncertainty in decision making, while Charles' project will focus on calibration of land use change models applied for natural hazard assessment.

Further details on Graeme and Charles' projects, and the roles of all researchers, are given in the section, 'Project team members'.

4.3. CONFERENCES AND PAPERS

Papers have been accepted for presentation at conferences, as listed below:

J. P. Newman, H. van Delden, H. R. Maier, G. C. Dandy, A. C. Zecchin and E. Pikusa (September 2014) "Integrated disaster decision support system incorporating mitigation portfolio optimisation" AFAC 2014 Conference, Wellington, New Zealand.

Charles P. Newland, Hedwig van Delden, Jeffrey P. Newman, Holger R. Maier and Aaron C. Zecchin (October 2014) "Enhanced understanding of Cellular Automata land use models by sensitivity analysis of key parameters" Urban Modelling – Toward Integrated Modelling of Urban Systems Conference, Lyon, France.

4.4. ENGAGEMENT

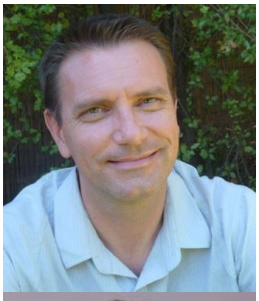
A blog has been created as an outlet for project updates, ideas and opinion pieces related to the project, and is located at http://blogs.adelaide.edu.au/natural-hazards/

Jeffrey Newman gave a presentation on the project before the AFAC Business Management Group, on the 11th of June. Feedback showed strong support for the project, although information management and integration of software systems across the research projects in the Economics and Strategic Decisions cluster was raised as an issue.

Jeffrey Newman participated in the CSIRO-Attorney General's Department Disaster Mitigation Workshop, held on 23rd of May. The workshop developed a vision for disaster mitigation in 2030, and identified research gaps that needed filling to achieve this. Our research project fills many of the identified gaps, being:

- Identifying mitigation options (understanding how tools, incentives, regulations and other instruments affect risk)
- Setting the highest priorities for mitigation investment (prioritising where mitigation investment should be targeted)
- Identifying the best mitigation options
- Better metrics to evaluation mitigation options

5. LIST OF CURRENT PROJECT TEAM MEMBERS:



Prof. Holger Maier (University of Adelaide)

Project Lead Researcher, responsible for ensuring that the project delivers to contractually agreed scope and budget, and also responsible for the project communication between end-users and the project team, and communication with the cluster Lead User Representative and Lead Researcher. Also responsible for supervision of post-doctoral fellow and PhD students.

Dr Aaron Zecchin (University of Adelaide)

Deputy project leader, co-supervision of post-doctoral fellow and PhD students, oversight of optimisation and development of overall process and decision support system.

A/Prof Hedwig van Delden (Research Institute for Knowledge Systems (RIKS) / University of Adelaide)

Key researcher, responsible for running participatory workshops with end-users, data/information/model integration, application and calibration of the Metronamica land use modelling framework for those cases it will be applied to, and development of DSS software. Also responsible for supervision of post-doctoral fellow and PhD students. Accountable to the Project Lead Researcher for delivery of the prototype DSSs.

Prof Graeme Dandy (University of Adelaide)

High level oversight on optimisation and development of overall process.

Dr Ariella Helfgott (University of Adelaide / University of Wageningen / Oxford University)

Assistance with running participatory workshops.

Jeffrey Newman (University of Adelaide)

Responsible for literature review, collection of available data, information and models, development of overall framework, development and implementation of optimisation component of the project, day-to-day running of the project.

Graeme Riddell (University of Adelaide)

Graeme's PhD project looks to develop a framework to handle knowledge uncertainty (an uncertain future state of the world) for decision making with a focus on natural hazard mitigation planning. For long planning horizons significant sources of uncertainty can impact on the quality of modelling and hence the appropriateness of any decision made based on these assumptions. The aim is to balance the need for quality decision making with a continuous stream of new data and policies implemented; this is to be achieved by formalising the comparison between optimal long term and short term decisions to best determine an adaptive decision making framework.

Charles Newland (University of Adelaide)

Spatially distributed models are an effective means for the assessment of policy and planning investment options for optimal natural hazard mitigation. To broaden the applicability of spatially distributed models and allow more effective and efficient usage by decision makers, Charles' research aims to improve their calibration procedure.

APPENDIX A

Data needs and datasets obtained for the South Australian Greater Adelaide case study.

Data	Obtained
Land use data	☒
Infrastructure networks	
roads	☒
ramps/exits to highways	
train stations	
train tracks	☒
Bus stops	
irrigation channels	
irrigation access points	
airports	
ports	
water pipelines for drinking water	
(Electricity transfer lines)	
Master plans for land allocation	
Land development Zone	☒
DEM	☒
Soil map	
groundwater maps	
rainfall	☒
temperature	☒
flood risk	
salinization	
Population demographics	
Population projections	☒
Employment trends	
Hazard	
GDP data	
Buildings or places with social, cultural or post-emergency function	
Others	
Bushfire protection areas	☒
Metropolitan open space system	☒
Local government areas	☒
Workplace atlas	
Building value/construction data - NEXIS	☒

APPENDIX B

This appendix specifies the workshop content and invited participants for the workshop planned for the 18th of September 2014 at the University of Adelaide

An agenda for the workshop is given below:

9:30	Opening remarks, introduction to researchers and overview of day's agenda. Participant information and consent issues.	Prof. Holger Maier
9:45	Summary of questionnaires and interviews, and demonstration of prototype decision support system	Assoc. Prof. Hedwig van Delden
10:10	First focus group session	Discussion on contents/usefulness of the system for SA case: policy options, external drivers, models, indicators
11:00	Morning tea break	
11:20	Second focus group session	Discussion on contents of the system beyond the SA case
12:10	Lunch break	
13:10	Third focus group session	Discussion on contents of the system beyond the SA case
14:00	Fourth focus group session	Discussion on usability of the system for use beyond the SA case
14:50	Afternoon tea break	
15:10	Evaluation	Discussion on the usefulness and on other matters arising from the workshop, and time given for participants to fill the post-workshop questionnaire.
16:00	Closing remarks – summarisation of the day	Ed Pikusa

In regard to the focus group sessions, this may be done either as an entire group, or in breakout groups (depending on numbers). Each group will include a facilitator (either Dr. Ariella Helfgott or A/Prof. Hedwig van Delden), and will use standard discussion techniques such as (1) 'get to know you' introductions of participants, (2) introductory questions to foster initial discussion on focus group topic, (3) question/answers to steer conversation across entire scope of focus group topic, or to steer conversation away from inappropriate or significantly out-of-scope topics, (4) drawing out conversation via summaries, reflective and clarification questions, and (5) group mind mapping.

A note taker will be present in all sessions to provide a written summary of the session's discussion.

The participants that have been invited are:

- Ed Pikusa SAFECOM: Pikusa.ed@safecom.sa.gov.au
- Rebecca Rush Commonwealth AGD: Rebecca.Rush@ag.gov.au
- Alen Slijepcevic Vic CFA: a.slijepcevic@cfa.vic.gov.au
- Joe Buffone Vic CFA: j.buffone@cfa.vic.gov.au
- David Nichols Vic CFA: D.Nichols@cfa.vic.gov.au
- Stuart Midgley NSW RFS: Stuart.Midgely@rfs.nsw.gov.au
- David Launder SA MFS: launder.david@samfs.sa.gov.au
- Ben McFadgen Vic SES: BENJAMIN.MCFADGEN@ses.vic.gov.au

Within SA, I would also suggest the following key members of SMAG for SA specific issues to do with the hazards in question

- Flood: Chrissie Bloss DEWNR Chrissie.Bloss@sa.gov.au
- Coastal: James Guy DEWNR James.Guy@sa.gov.au
- SES: Bob Stevenson: Stevenson.Robert@ses.sa.gov.au
- Bushfire: Mike Wouters DEWNR Mike.Wouters@sa.gov.au
- CFS: Andrew Lawson Lawson.Andrew@cfs.sa.gov.au
- Earthquake: Shane Turner DPTI Shane.Turner@sa.gov.au
- SAPOL: Russell Dippy Russell.Dippy@police.sa.gov.au
- Bureau of Met (storms and heatwaves): John Nairn: J.Nairn@bom.gov.au

Other stakeholders of note from interstate (ask them if there are others they should also invite)

- Brenton Keen (SA) Keen.Brenton@safecom.sa.gov.au
- Paul Gabriel (Vic) paul.gabriel@justice.vic.gov.au
- Greg Christopher (Vic) greg.christopher@justice.vic.gov.au
- Andrew Sanders (WA) Andrew.Sanders@semc.wa.gov.au
- Mat Healey (Tas) Mathew.healey@dpac.tas.gov.au
- Leesa Carson (Geoscience Australia) leesa.carson@ga.gov.au
- Wendy Graham (NSW) Wendy.Graham@mpes.nsw.gov.au
- Robert Preston (Qld) robert.preston@dcs.qld.gov.au
- Virginia Hayward (ACT) Virginia.Hayward@act.gov.au