SPATIAL DECISION SUPPORT SYSTEM FOR NATURAL HAZARD RISK REDUCTION POLICY ASSESSMENT AND PLANNING

Holger Maier, Hedwig van Delden, Graeme Riddell, Jeffrey Newman, Aaron Zecchin, Graeme Dandy and Charles Newland
MOTIVATION
NATURAL DISASTERS ARE EXPENSIVE

Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state

$bn (2015 prices)

Source: Deloitte Access Economics analysis
Is there anything we can do about this?
“Better to build a fence at the top of a cliff, than park an ambulance at the bottom”

Helen Clark 2015 Sendai
PREVENTION IS BETTER THAN CURE

COST

BENEFIT

$bn (2015 prices)

x 1 Recovery

x 4 Mitigation

Source: Deloitte Access Economics analysis

bnhcrc.com.au
RISK REDUCTION & MITIGATION

“Better to build a fence at the top of a cliff, than park an ambulance at the bottom”

Helen Clark 2015 Sendai

Where to put the fence?
How high should it be?
When to build it?
A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

- Generic Framework
- Adelaide Case Study
- Melbourne and Tasmania Case Studies
- Conclusions
- Future Plans
A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

Generic Framework

Adelaide Case Study

Melbourne and Tasmania Case Studies

Conclusions

Future Plans
GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

Case Study Application
GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

Case Study Application
<table>
<thead>
<tr>
<th>People</th>
<th>Land</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural diversity</td>
<td>Residential</td>
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</tr>
<tr>
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<td>Vegetation</td>
<td>Critical infrastructure</td>
</tr>
<tr>
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<td>Agriculture</td>
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</tr>
<tr>
<td>Age profile</td>
<td>Industry</td>
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</tbody>
</table>
### Natural Hazards
- Bushfire
- Flooding
- Coastal inundation
- Earthquake
- Heatwave

### Exposure

#### Vulnerability

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**Note:** The diagram illustrates the relationship between natural hazards and exposure vulnerability, highlighting the components of exposure and vulnerability.
Natural Hazards
- Bushfire
- Flooding
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- Earthquake
- Heatwave

Vulnerability

People
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- Socio-econ status
- Well-being
- Age profile

Land
- Residential
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- Agriculture
- Industry

Infrastructure
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- Critical infrastructure
- Culturally significant areas

Impact & Consequences
- Community
- Ecology
- Economy
- Amenity
- Vulnerable groups
- Level of service
Impact & Consequences
- Community
- Ecology
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- Vulnerable groups
- Level of service

Risk Reduction
- Landuse planning
- Community education
- Structural measures

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MODEL

MODEL
PREVENTION IS BETTER THAN CURE

COST

BENEFIT

x 1 Recovery

x 4 Mitigation

Source: Deloitte Access Economics analysis

bnhcrc.com.au
An uncertain future, deep uncertainty, scenarios, robustness and adaptation: How do they fit together?

H.R. Maier a, J.H.A. Guillaume b, H. van Delden a, c, G.A. Riddell a, M. Haasnoot d, e, J.H. Kwakkel

a School of Civil, Environmental and Mining Engineering, The University of Adelaide, Adelaide SA 5005, Australia
b Water & Development Research Group (WDRG), Aalto University, Tietoje 1E, Espoo 02150, Finland
c Research Institute for Knowledge Systems, Hertogsgang 11B, 6211 NC Maastricht, The Netherlands
d Deltares, Fresh Water Department, Delft, The Netherlands
e Delft University of Technology, Faculty of Technology Policy and Management, Delft, The Netherlands
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Exposure

- Vulnerability

"MODEL LONG-TERM CHANGES"
WHAT CAN THE SYSTEM DO?

- Identify **areas of risk**, now and into the future
- Test different **types of risk reduction options**
- Identify / suggest **mitigation portfolios** that provide best outcomes for a given budget
- Consider **single or multiple hazards**
- Consider **single or multiple types of risk reduction options**

**Exposure**

**Vulnerability**

- **People**
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  - Socio-economic status
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- **Land**
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**Risk Reduction**

- Landuse planning
- Community education
- Structural measures

“MODEL LONG-TERM CHANGES”
GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

Case Study Development and Use
Risk

Exposure

People
Risk

Exposure

- People
- Economy
- Land use model
- Building stock model
Risk

Hazard

Hazard Model

Exposure

Vulnerability

People

Economy

Land use model

Building stock model

Building vulnerability curves

Building stock model

Fatality curves

Hazard

People

Economy

Land use model

Building stock model

Building vulnerability curves

Building stock model

Fatality curves

Hazard Model

Heatwave

Flooding

Bushfire

Coastal Inundation

Earthquake
Risk

Hazard Model

Hazard

Indicators:
- Expected damage maps
- Expected fatality maps

Exposure

Vulnerability

People
Economy
Land use model
Building stock model

Building vulnerability curves
Building stock model
Fatality curves

Heatwave
Flooding
Bushfire
Coastal Inundation
Earthquake
GENERIC FRAMEWORK

Conceptual Approach

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Software Framework

Case Study Development and Use
SYSTEM DIAGRAM
LANDUSE ALLOCATION
EARTHQUAKE

Hazard
Vulnerability
Mitigation
Output
MODELLER INTERFACE EARTHQUAKE
Hazard Map
EARTHQUAKE

Vulnerability Curves
EARTHQUAKE

Retrofitting Options
EARTHQUAKE

Modified Vulnerability Curves
(after Retrofitting)
EARTHQUAKE

Earthquake average annual loss

Dynamic Output Map
Expected average annual loss from earthquakes 2013-2050
BUSHFIRE

Suppression
BUSHFIRE

Time Since Last Fire (TSLF)

Time Since Last Fire
BUSHFIRE

Vegetation types

Vegetation
BUSHFIRE

Landuse Planning (Zoning)
Dynamic Output Maps
RIVERINE FLOODING

Hazard
Vulnerability
Mitigation
Output
RIVERINE FLOODING

1 in 20 Year Flood (Current Conditions)
RIVERINE FLOODING

1 in 100 Year Flood (Current Conditions)
RIVERINE FLOODING

1 in 100 Year Flood (with Mitigation)
COASTAL INUNDATION

Hazard

Vulnerability

Mitigation

Output
COASTAL INUNDATION

1 in 20 Year Event (Current Conditions)
COASTAL INUNDATION

1 in 100 Year Event (RCP 8.5)
SCENARIO ANALYSIS
GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

Case Study Development and Use
1) Questionnaires
2) Semi-structured interviews
3) Workshop 1 (requirements, policy setting, use)
4) System development (data, models integration, GUI)
5) Workshop 2 (feedback)
6) System modification
SCENARIO INPUTS

1) Questionnaires
2) Semi-structured interviews
3) Workshop 2 (scenario construction)
APPROACH TO SCENARIO DEVELOPMENT

Future challenges for resilience vs. Future challenges for mitigation

- S. 1
- S. 2
- S. 3
- S. 4
- S. 5
SCENARIO OUTPUTS

1) Modelling of scenarios
2) Workshop 3 (scenario validity and outputs)
BENEFITS OF PROPOSED APPROACH

End users involved in:
- Model development & selection
- User interface design
- Scenario development
- Policy assessment & planning

Social learning occurs when stakeholders, modellers and facilitators explore and evaluate policy options through group interaction with the DSS.

Builds strategic capacity by exploring future risk profiles

Looks towards integration of system within organisations.
A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

Generic Framework

Adelaide Case Study

Melbourne and Tasmania Case Studies

Conclusions

Future Plans
SYSTEM DIAGRAM
SCENARIOS FOR GREATER ADELAIDE

Future challenges for mitigation

Future challenges for resilience

Ignorance of the Lambs
Silicon Hills
Appetite for Change
Cynical Villagers
Internet of Risk
Scenario 1: Silicon Hills

Silicon Hills

Cynical Farmer

Ignorance of the Lambs

Appetite for Change

Internet of Risk

Future challenges for resilience

Future challenges for mitigation

Silicon Hills

Cynical Villagers

Appetite for Change

Stars

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Technology driven economy
Fuelled by skilled locals and immigrants
Enjoying the nature and lifestyle of Adelaide
High multi-culturalism, and appreciation of risks
Work flexibility, encouraging community spirit
Emphasis on urban design and building resilience
Scenario 2: Cynical Villagers

Silicon Hills

Internet of Risk

Ignorance of the Lambs

Appetite for Change

Future challenges for mitigation

Future challenges for resilience

Silicon Hills

Cynical Villagers
Ageing population, slowing population growth
Growth in rural residential living, mixed with agriculture and nature
Shift from manufacturing to small scale agriculture
Increasingly inward looking economy
Strong community strength, will challenge government interventions
Low emphasis on technology & innovation, return to cottage-industries
Scenario 3: Ignorance of the Lambs

Future challenges for mitigation

Future challenges for resilience

Ignorance of the Lambs

Internet of Risk

Appetite for Change

Silicon Hills

Cynical Villagers
Large population growth, high immigration
Increasing commuter lifestyle, low cost housing
Loss of manufacturing, economic decline
Increasing community vulnerability & government reliance
Those who can leave do so
Ageing infrastructure, poorly maintained
Scenario quantification
# Main scenario drivers and outcomes

<table>
<thead>
<tr>
<th></th>
<th>Silicon Hills</th>
<th>Cynical Villagers</th>
<th>Ignorance of the Lambs</th>
<th>Appetite for Change</th>
<th>Internet of Risk</th>
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</thead>
<tbody>
<tr>
<td>Population in 2050</td>
<td>1.9 M</td>
<td>1.5 M</td>
<td>2.5 M</td>
<td>1.8 M</td>
<td>1.5 M</td>
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<td>Economy</td>
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<tr>
<td>Community resilience</td>
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<tr>
<td>Building stock resilience</td>
<td></td>
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<tr>
<td>Residential land use developments</td>
<td>Gradual growth urban and rural areas</td>
<td>Large increase in rural residential, mixed with other land uses</td>
<td>Residential commuter communities in the hills</td>
<td>Infill, some sprawl on the fringe and rural residential development</td>
<td>Large increase in rural residential</td>
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<tr>
<td>Land use planning</td>
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<tr>
<td>Education &amp; awareness</td>
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<tr>
<td>Structural mitigation</td>
<td></td>
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APPETITE FOR CHANGE – LAND USE CHANGE
IGNORANCE OF THE LAMBS – LANDUSE CHANGE
CYNICAL VILLAGERS– LANDUSE CHANGE
INTERNET OF RISK – LANDUSE CHANGE
FLOOD DAMAGE (1 IN 500)

APPETITE FOR CHANGE

Total Damage ($million)

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High : 8.894</td>
</tr>
<tr>
<td>Low : 0</td>
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FLOOD DAMAGE (1 IN 500)

IGNORANCE OF THE LAMBS

Total Damage ($million)

Value
- High : 8.894
- Low : 0
FLOOD DAMAGE (1 IN 500)

CYNICAL VILLAGERS

Total Damage ($million)

Value
- High : 8.894
- Low : 0
FLOOD DAMAGE (1 IN 500)

INTERNET OF RISK

Total Damage ($million)

Value
- High : 8.894
- Low : 0
BUSHFIRE - 2050
COASTAL INUNDATION - 2050

Silicon Hills – High Mitigation

Internet of Risk – Low Mitigation
NEXT STEPS

1) Refine results (linking with other CRC projects)

2) Finalise software

3) Add formal optimisation capability

4) Final workshop (#4)
A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

Generic Framework

Adelaide Case Study

Melbourne and Tasmania Case Studies

Future Plans

Conclusions
MELBOURNE AND TASMANIA CASE STUDIES

First workshops held

Data collection well under way

Model development commencing

Prototypes completed by October this year

Scenario workshops in October - December
A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

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<table>
<thead>
<tr>
<th>Scoping</th>
<th>Utilisation</th>
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<tbody>
<tr>
<td><strong>Function and use</strong></td>
<td></td>
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<tr>
<td>Specified</td>
<td>G</td>
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<tr>
<td></td>
<td>Y</td>
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<td></td>
<td>R</td>
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<tr>
<td><strong>Hazards</strong></td>
<td></td>
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<tr>
<td>Geophysical</td>
<td>O</td>
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<tr>
<td><strong>End-users and operators</strong></td>
<td></td>
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<tr>
<td>Reported on</td>
<td>Y</td>
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<td>Spatially explicit</td>
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<td><strong>Problem Formulation</strong></td>
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<td><strong>Risk reduction measures</strong></td>
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<tr>
<td>Structural options</td>
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<td><strong>External drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Y</td>
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<tr>
<td><strong>Criteria</strong></td>
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<tr>
<td>More than pure hazard criteria used (e.g. risk based)</td>
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<td><strong>Analysis framework</strong></td>
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<td>Model selection</td>
<td>G</td>
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<tr>
<td>Evaluating mitigation options and developing plans</td>
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<td><strong>User and organisational interaction with the system</strong></td>
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<td>Specifying criteria for enduser requirements</td>
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<td>GUI design and development</td>
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<td>Enduser engagement and consideration of different types of users</td>
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<td><strong>Use and user engagement</strong></td>
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<td>Non-hazard scenarios used</td>
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<td>Training conducted</td>
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<tr>
<td><strong>Monitoring and evaluation</strong></td>
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<td>Monitoring and evaluation process</td>
<td>R</td>
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UTILISATION ACTIVITIES

1) Adoption of 3 case study DSSs
   a) Adelaide
   b) Melbourne
   c) Tasmania

   Customisation of platform for specific decision contexts
   Capacity building / training / institutional arrangements

2) Generalisation of application to different types of case studies
   a) Regional grouping of councils (e.g. QLD)
   b) Single hazard agency (e.g. NSW SES)
   c) Central planning agency (e.g. SA DPC)
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NATURAL DISASTERS ARE EXPENSIVE

Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state

Source: Deloitte Access Economics analysis
NATURAL DISASTERS ARE EXPENSIVE

But we can do something about this!

Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state

Source: Deloitte Access Economics analysis
MAJOR OUTCOMES

1) A systematic and transparent approach to evaluating natural hazard mitigation options.

2) A framework for making more strategic and less responsive decisions.

3) The ability to sift through, evaluate and rank a large number of risk reductions options.

4) Understanding the trade-offs between economic, environmental and/or social objections for mitigation options.

5) Building strategic capacity across governments and agencies for considering the future challenges of natural hazard risk in dynamic and growing regions.

6) Three proto-type systems for Greater Adelaide, Greater Melbourne and Tasmania
THANK YOU

Holger Maier
holger.maier@adelaide.edu.au