bushfire&natural HAZARDSCRC

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

An Australian Government Initiative

CRC AUSTRALIA

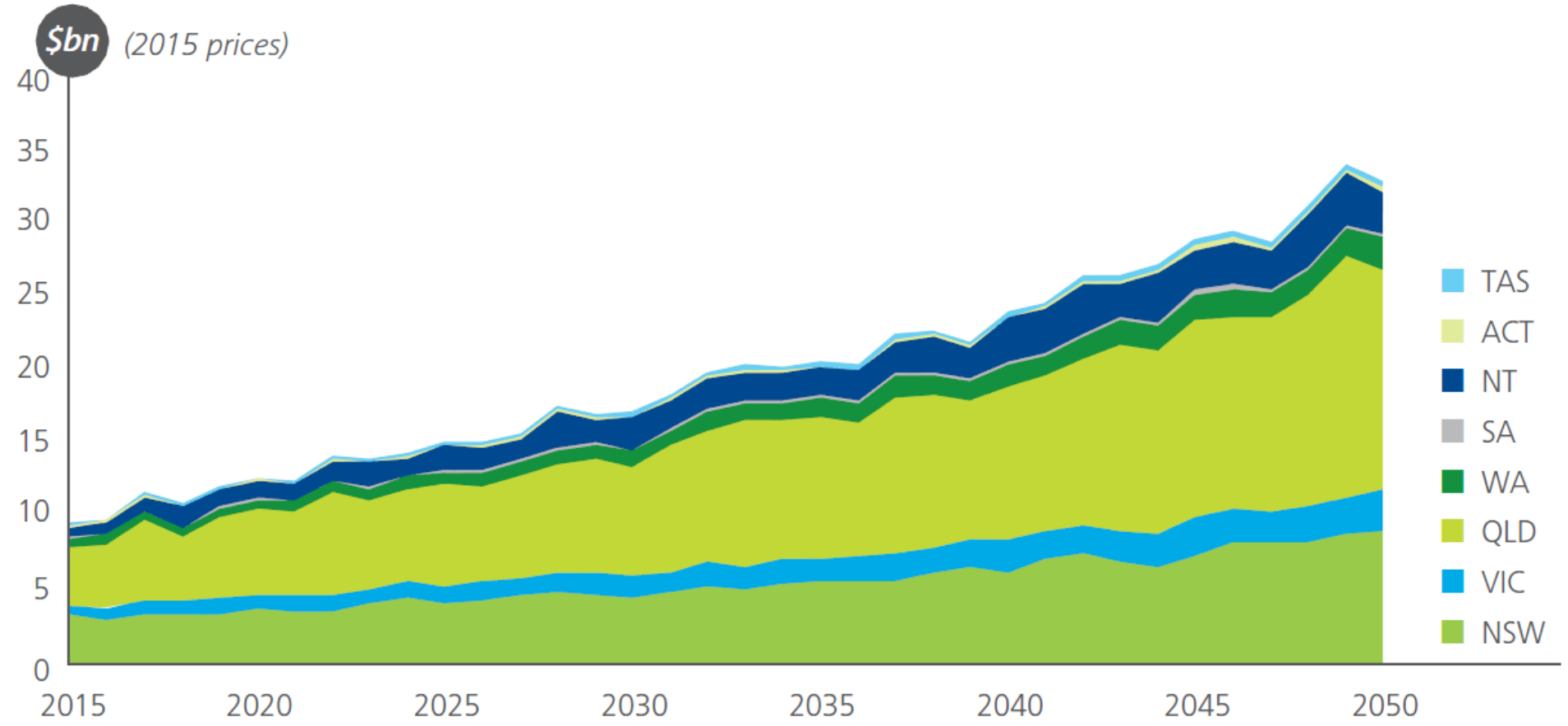
THE UNIVERSITY of ADELAIDE

RIKS research institute for knowledge systems

MOTIVATION

NATURAL DISASTERS ARE EXPENSIVE

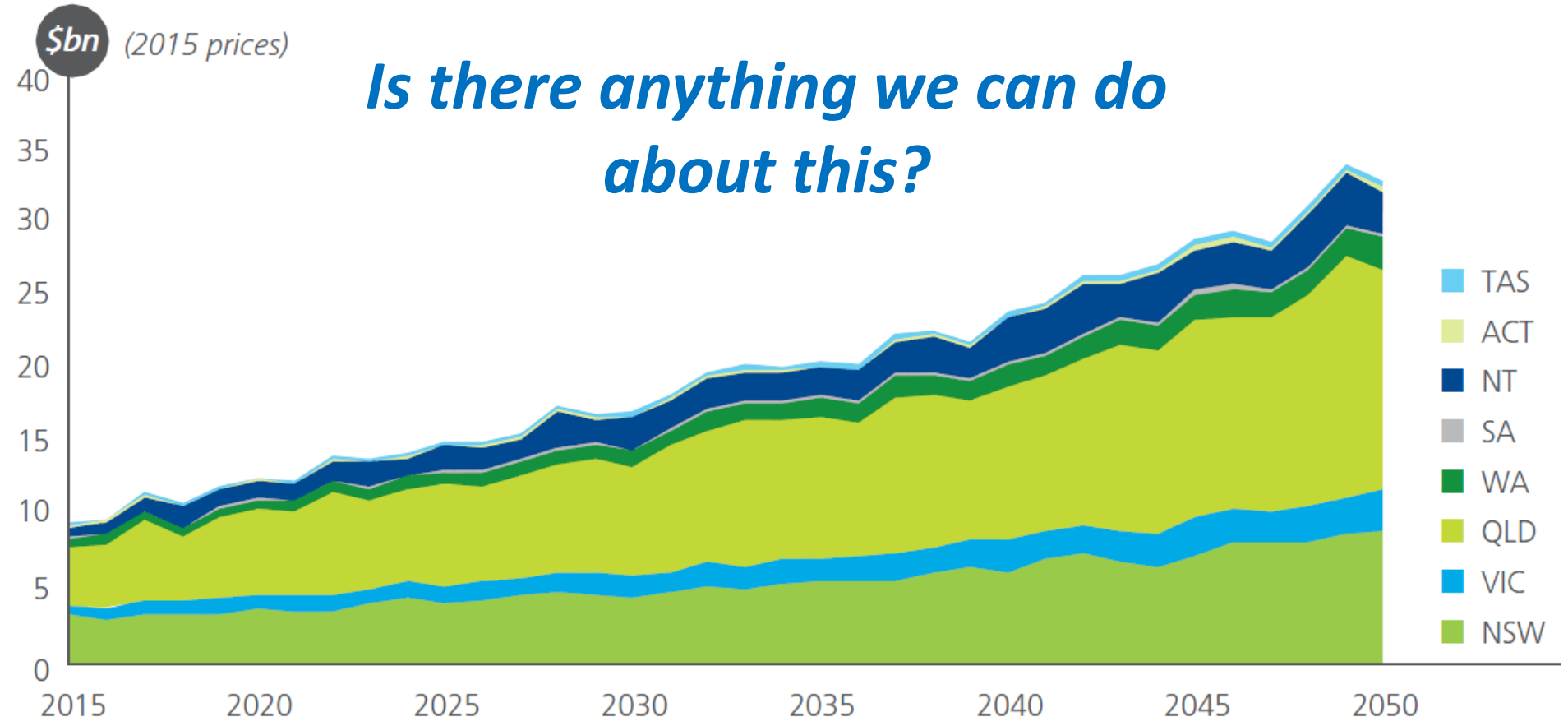
Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state



Source: Deloitte Access Economics analysis

NATURAL DISASTERS ARE EXPENSIVE

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



Is there anything we can do about this?

Source: Deloitte Access Economics analysis

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

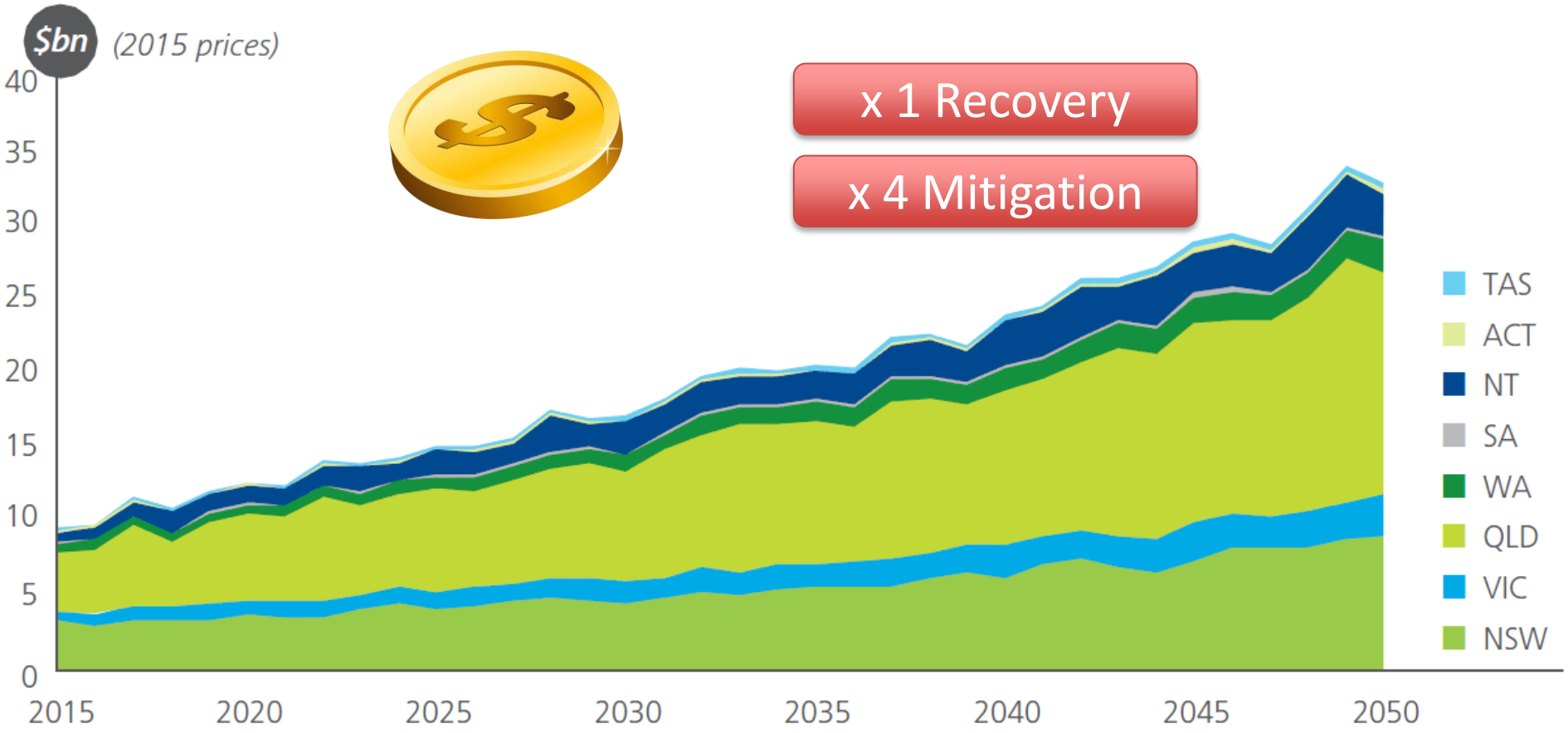
PREVENTION IS BETTER THAN CURE

COST

BENEFIT

x 1 Recovery

x 4 Mitigation



Source: Deloitte Access Economics analysis

RISK REDUCTION & MITIGATION

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

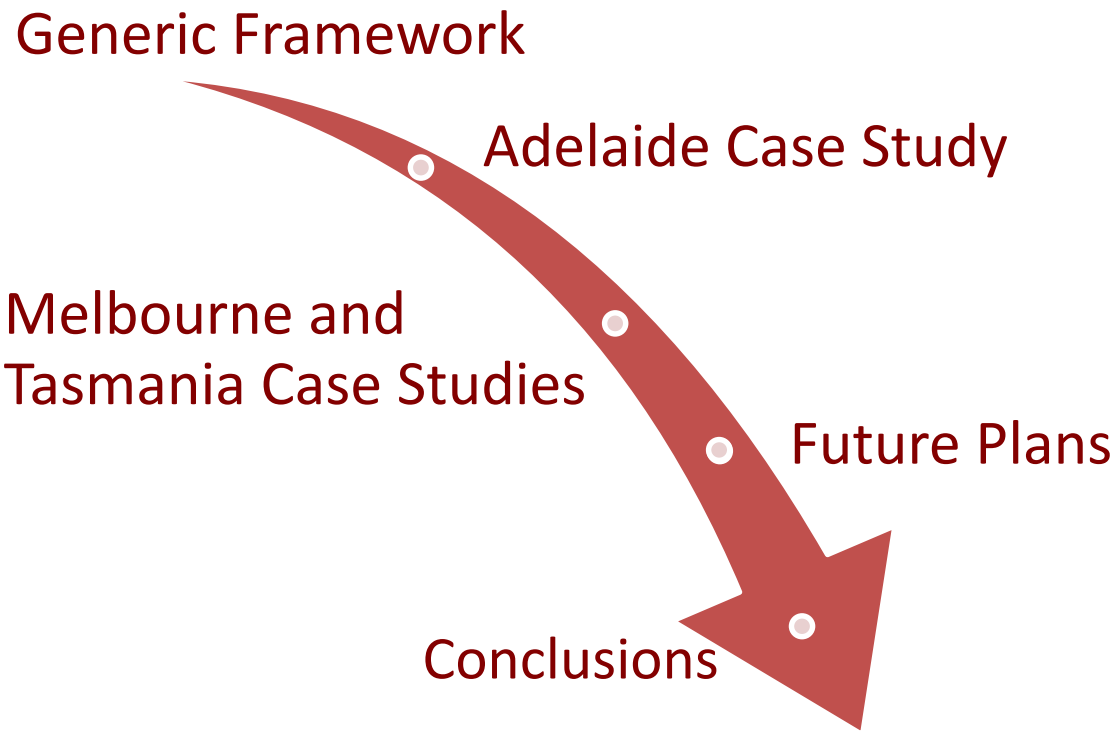
Helen Clark 2015 Sendai

Where to put the fence?

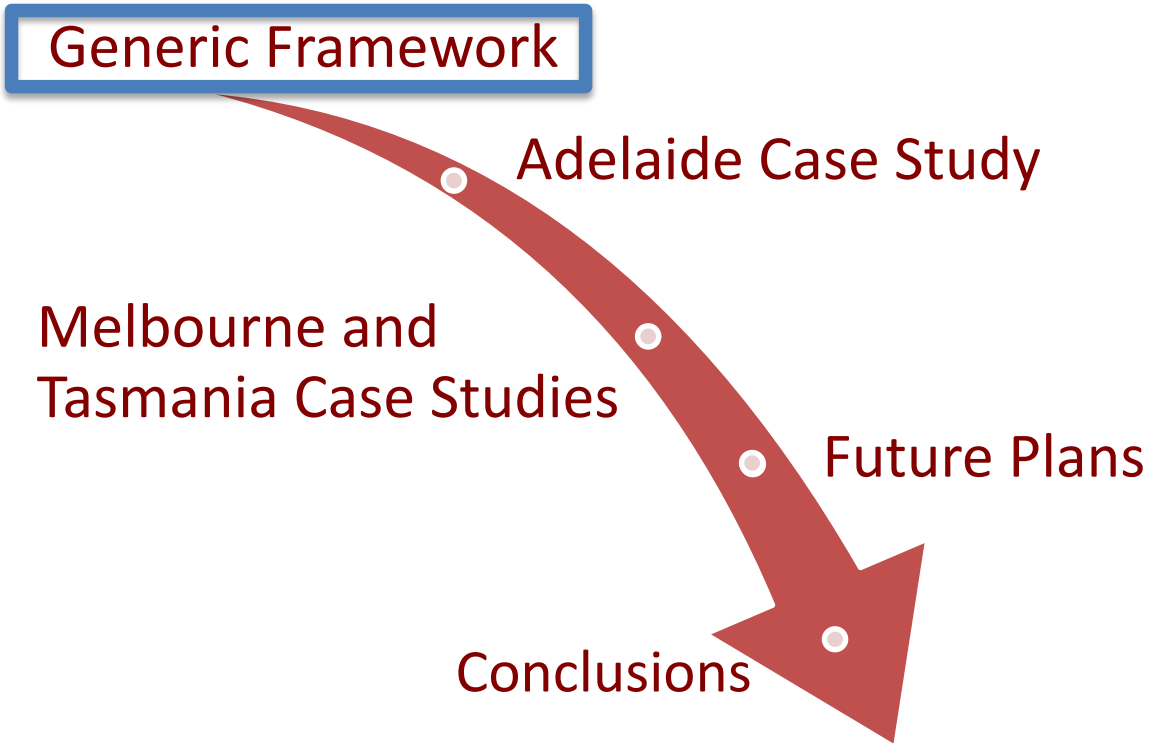
How high should it be?

When to build it?

A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation



A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation



GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

Case Study Application

GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

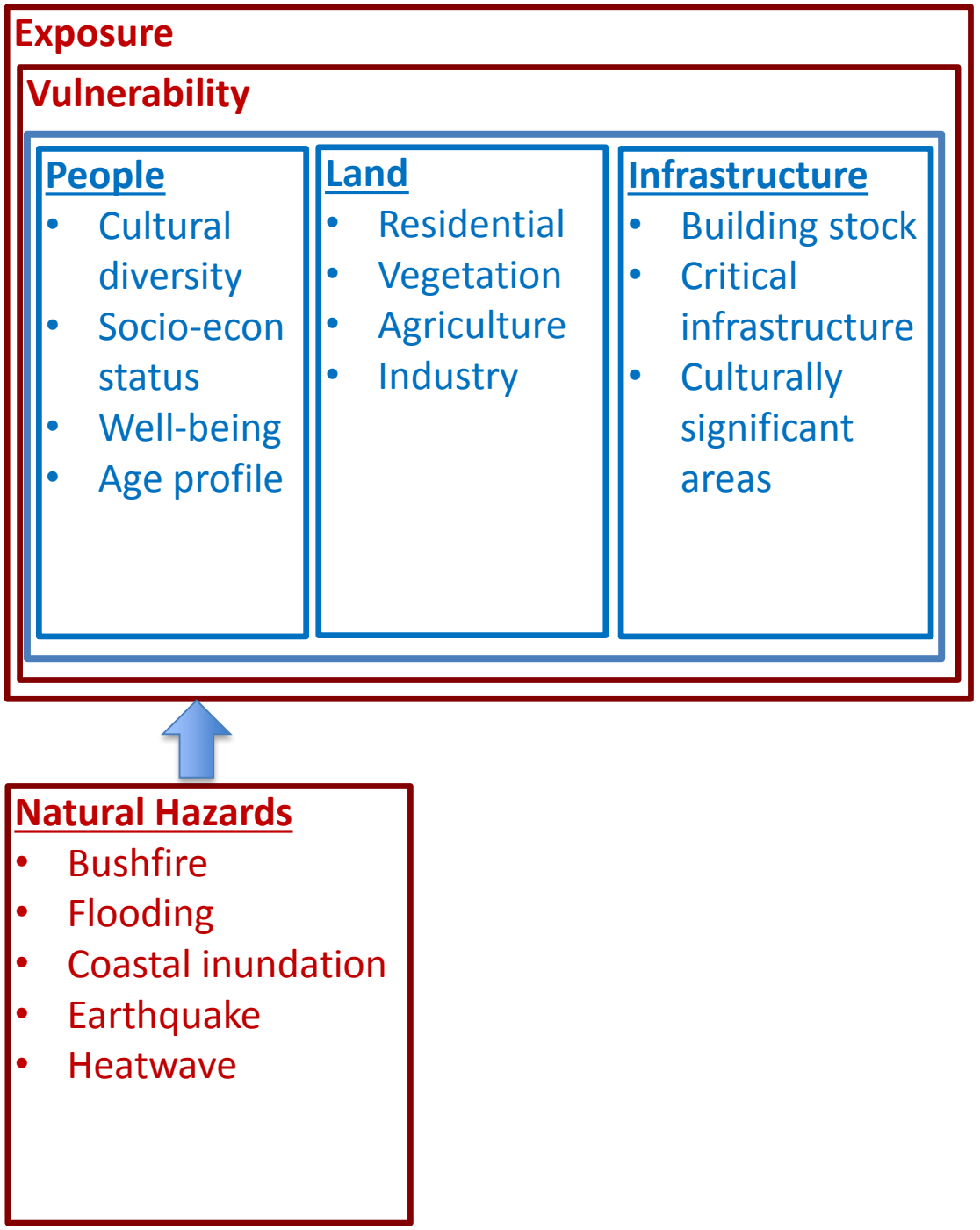
Case Study Application

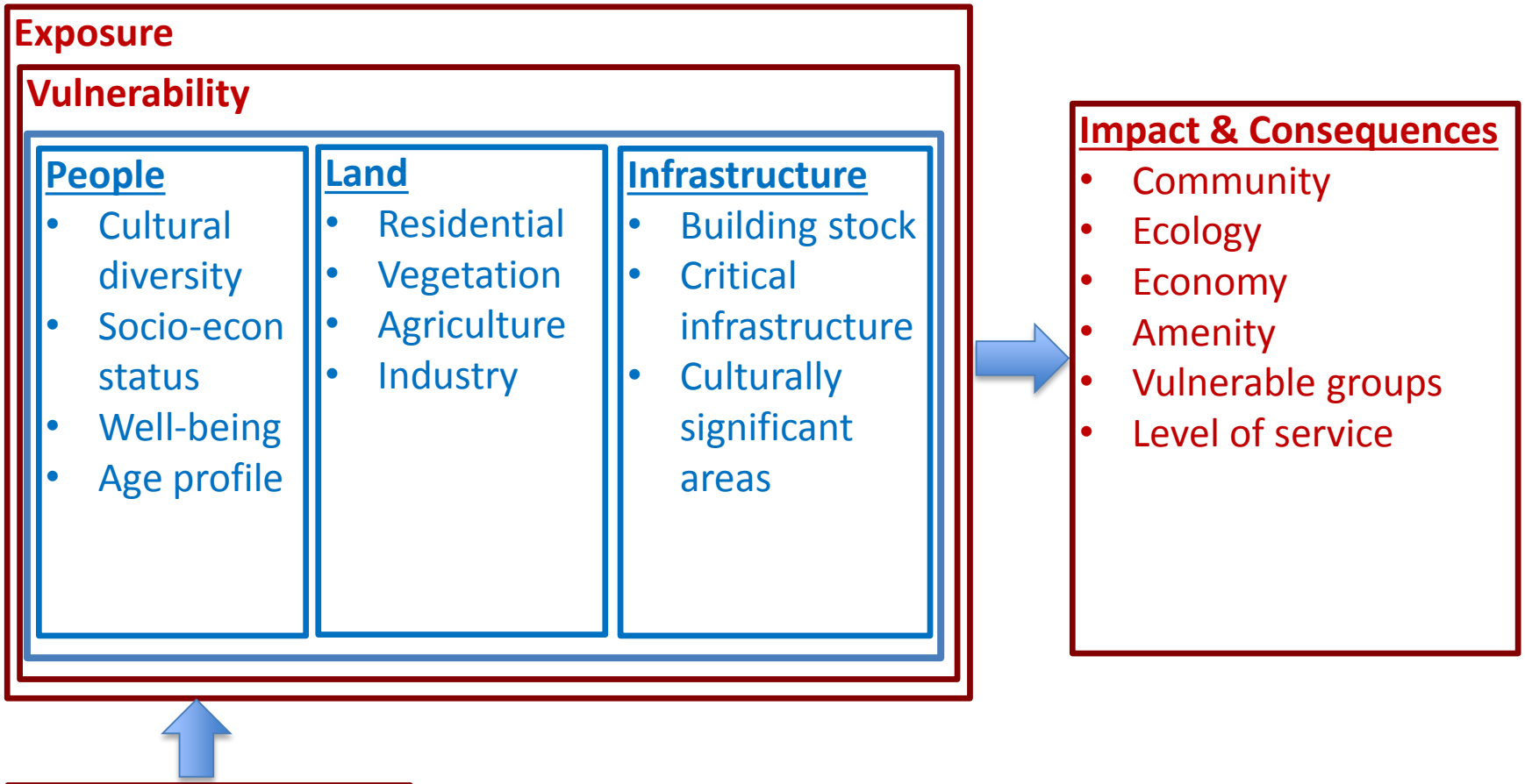
Vulnerability

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

Land
- Residential
- Vegetation
- Agriculture
- Industry

Infrastructure
- Building stock
- Critical infrastructure
- Culturally significant areas


Exposure
Vulnerability
People
• Cultural diversity
• Socio-econ status
• Well-being
• Age profile
Land
• Residential
• Vegetation
• Agriculture
• Industry
Infrastructure
• Building stock
• Critical infrastructure
• Culturally significant areas
Natural Hazards
• Bushfire
• Flooding
• Coastal inundation
• Earthquake
• Heatwave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Impact & Consequences
• Community
• Ecology
• Economy
• Amenity
• Vulnerable groups
• Level of service
Natural Hazards
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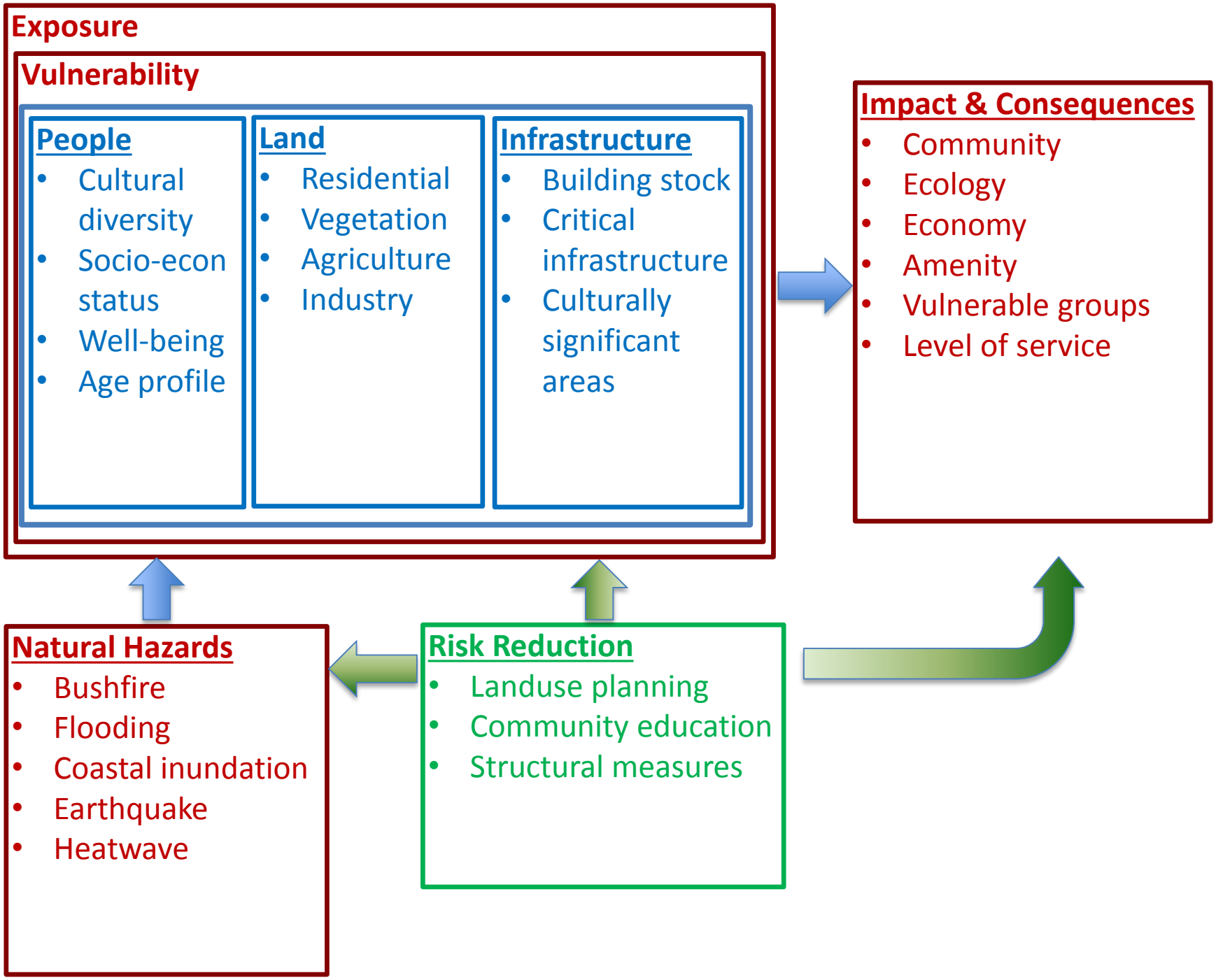
Exposure
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Ecology
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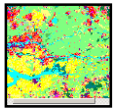
Flooding
Coastal inundation
Earthquake
Heatwave
Risk Reduction
Landuse planning
Community education
Structural measures

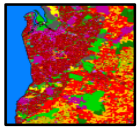
Exposure

Vulnerability

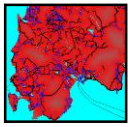
People
- Cultural diversity
- Socio-econ status
- Well-being
- Age profile



Land
- Resi[illegible]
- [illegible]

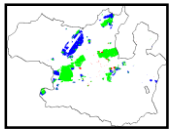


Infrastructure
- Building stock
- [illegible]ical infrastructure
- Culturally significant areas



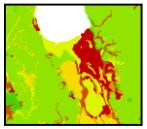
MODEL

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



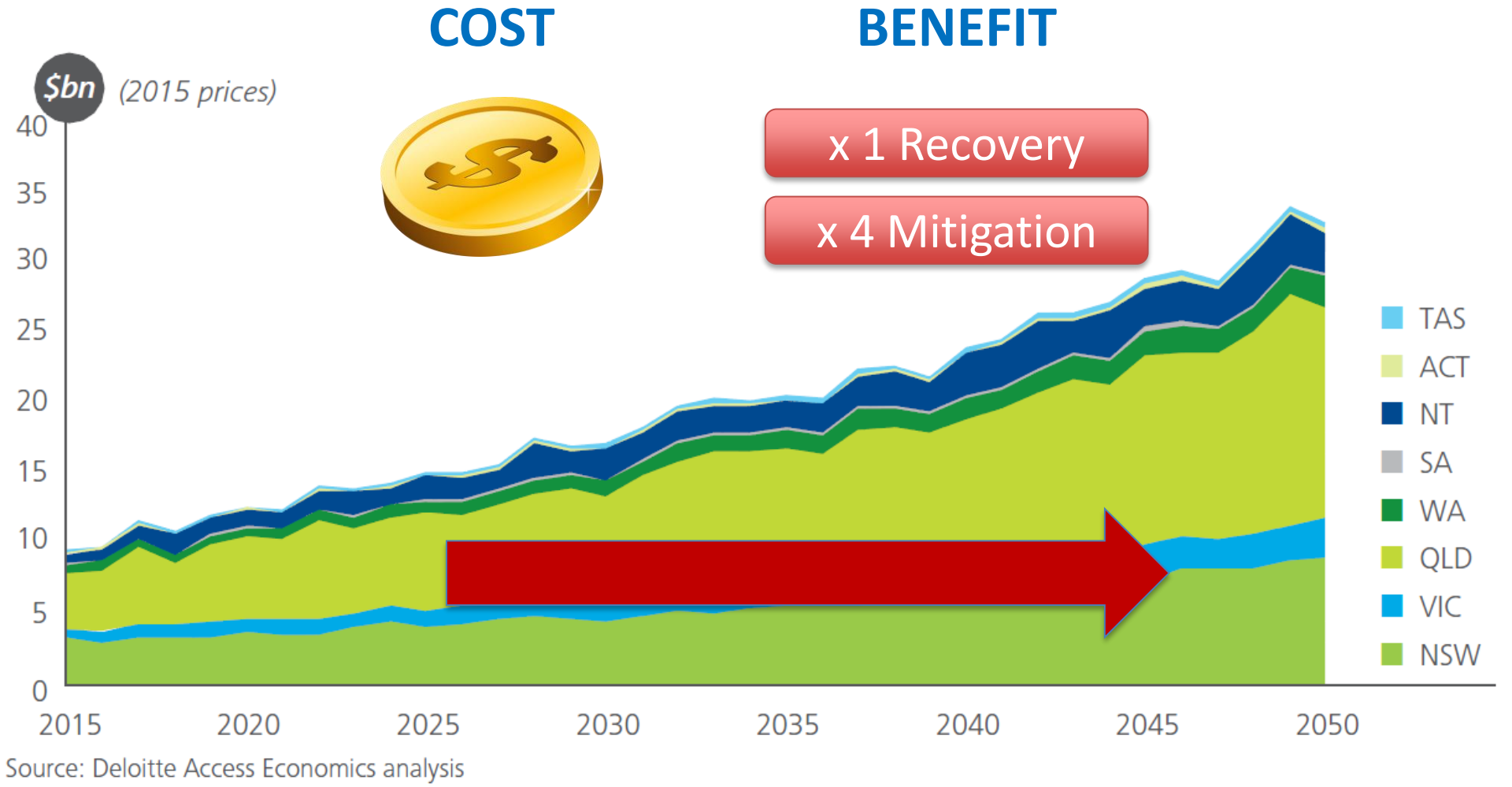
Natural Hazards
- Bushfire
- F[illegible]
- [illegible]dation
- [illegible]e
- H[illegible]atwave

MODEL



Risk Reduction
- Landuse planning
- Community education
- Structural measures

PREVENTION IS BETTER THAN CURE



Source: Deloitte Access Economics analysis

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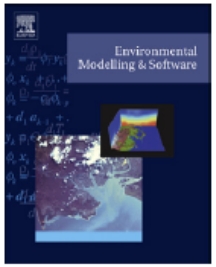
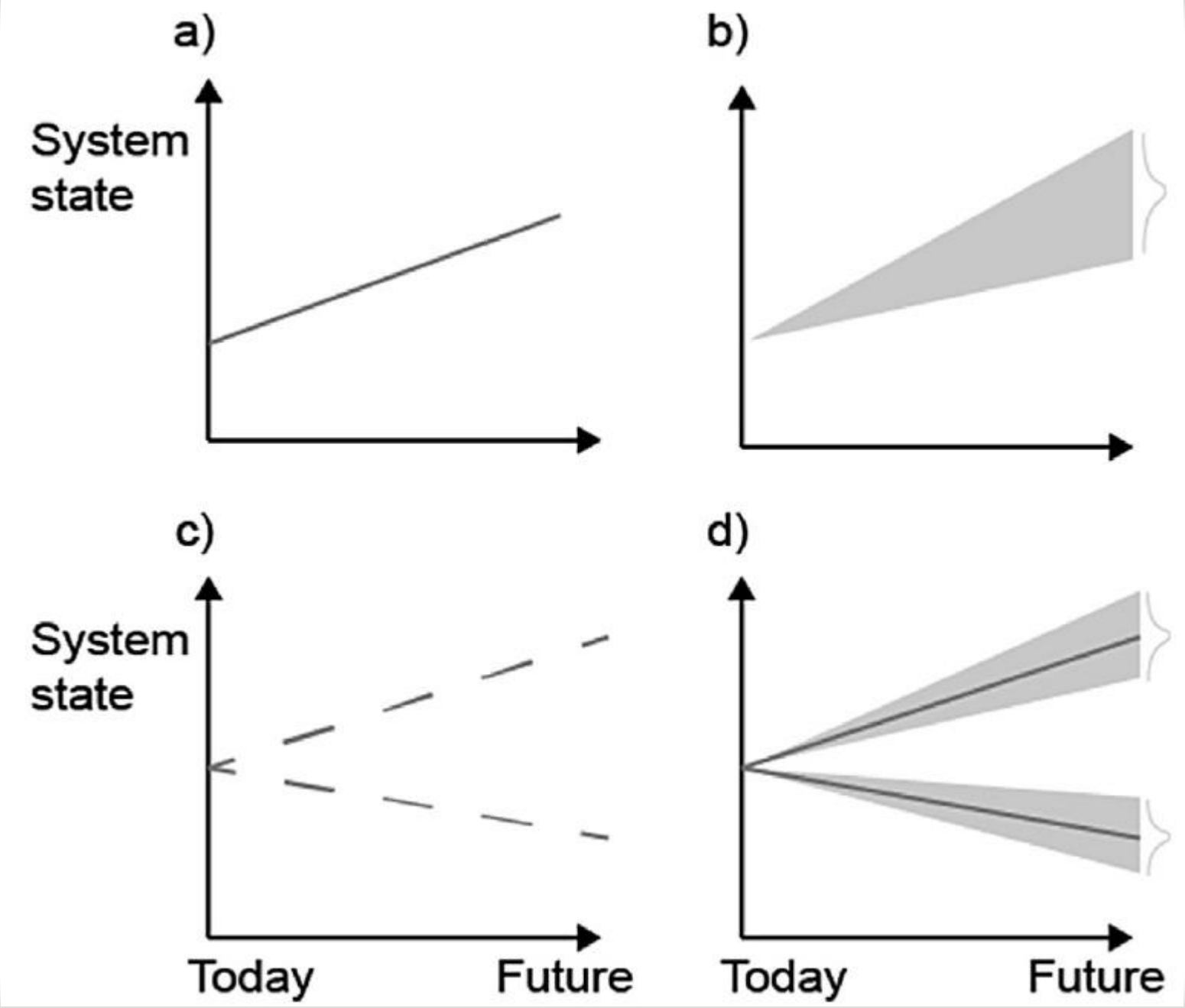
journal homepage: www.elsevier.com/locate/envsoft

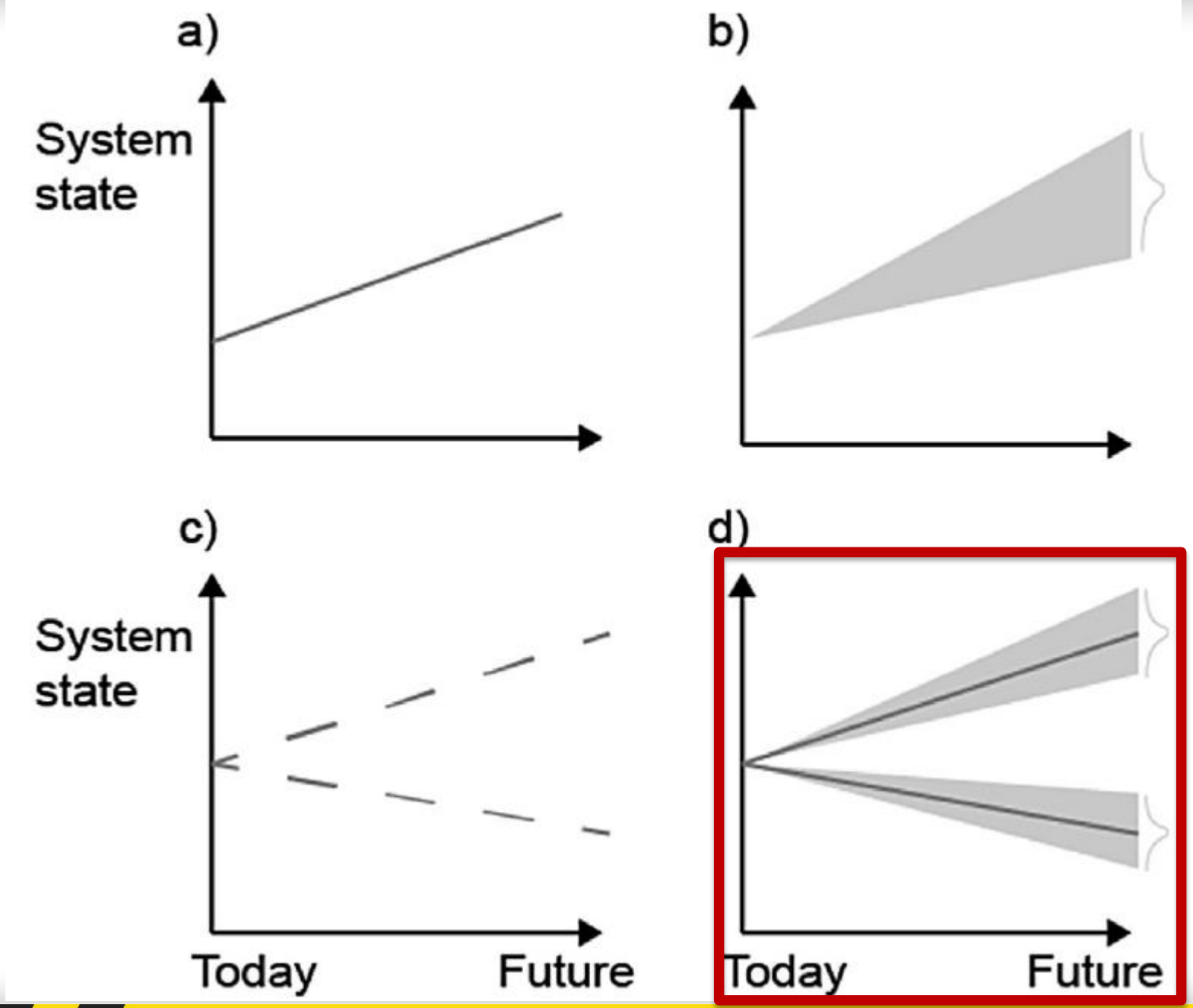


An uncertain future, deep uncertainty, scenarios, robustness and adaptation: How do they fit together?

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 [e]

[a] School of Civil, Environmental and Mining Engineering, The University of Adelaide, Adelaide SA 5005, Australia
[b] Water & Development Research Group (WDRG), Aalto University, Tietotie 1E, Espoo 02150, Finland
[c] Research Institute for Knowledge Systems, Hertogsingel 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


a)
System state
b)
c)
System state
Today
Future
d)
Today
Future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d)
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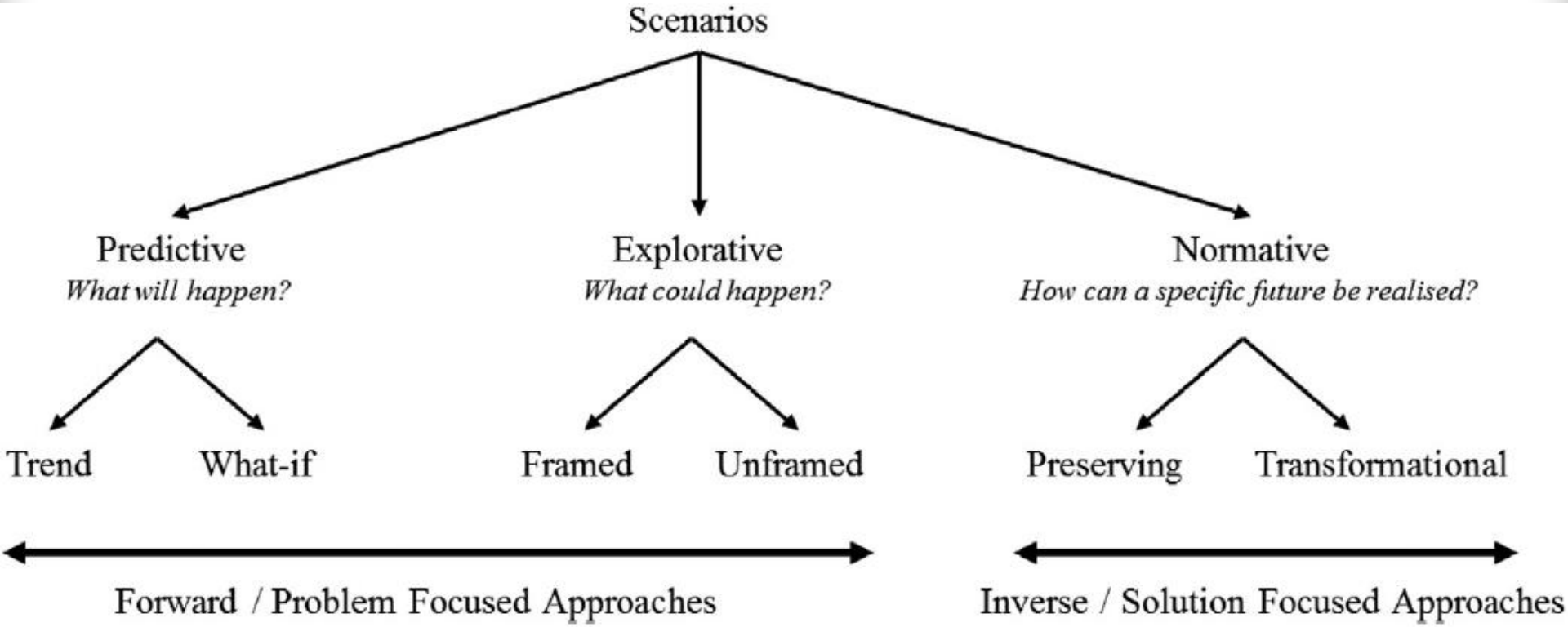
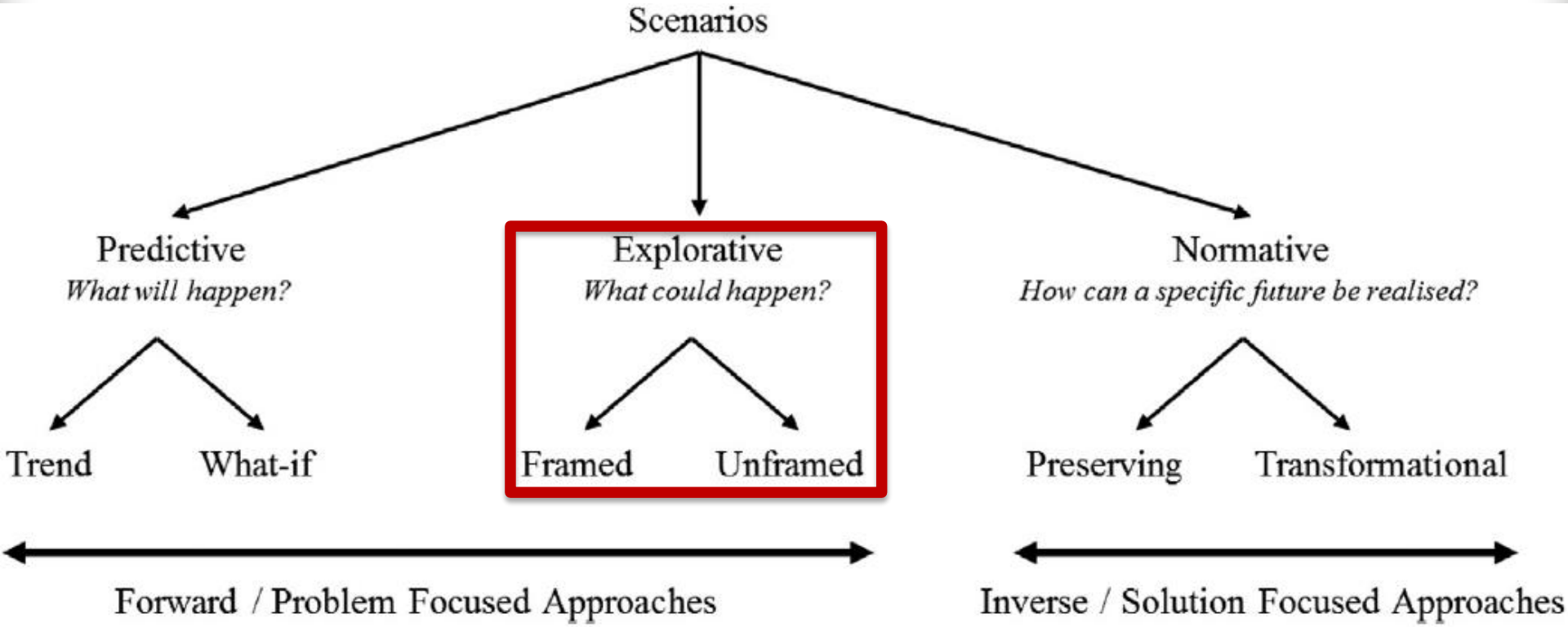
Future


Scenarios
Predictive
What will happen?
Explorative
What could happen?
Normative
How can a specific future be realised?
Trend
What-if
Framed
Unframed
Preserving
Transformational
Forward / Problem Focused Approaches
Inverse / Solution Focused Approaches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Forward / Problem Focused Approaches
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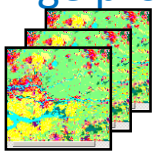
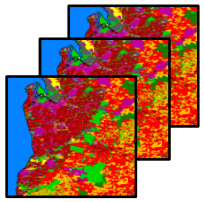
Exposure

Vulnerability

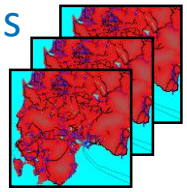
People
- Cultural diversity
- Socio-econ status
- Well-being
- Age profile



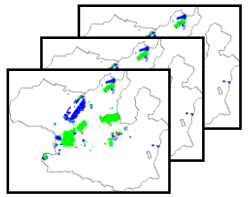
Land
- Residential
- Vegetation
- Agriculture
- Industry



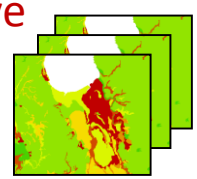
Infrastructure
- Building stock
- Critical infrastructure
- Culturally significant areas



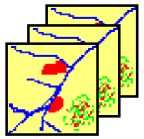
Impact & Consequences
- Community
- Ecology
- Economy
- Amenity
- Vulnerable groups
- Level of service



Natural Hazards
- Bushfire
- Flooding
- Coastal inundation
- Earthquake
- Heatwave

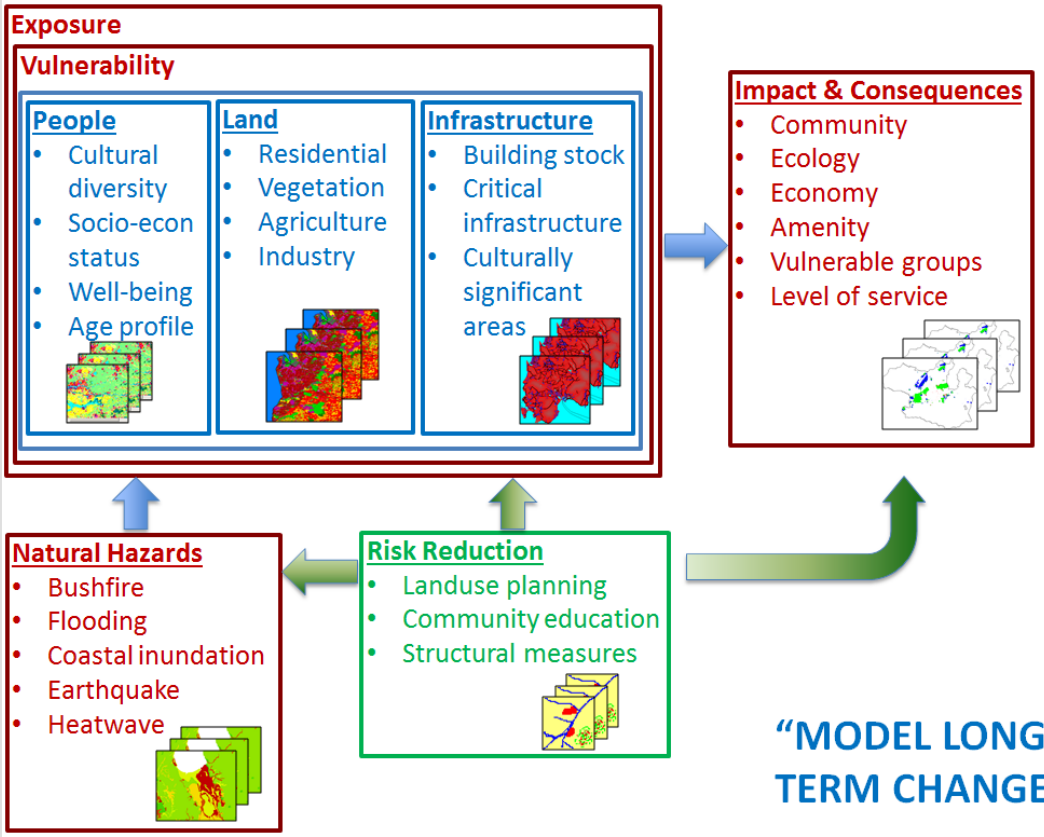


Risk Reduction
- Landuse planning
- Community education
- Structural measures



“MODEL LONG-TERM CHANGES”

WHAT CAN THE SYSTEM DO?



"MODEL LONG-TERM CHANGES"

- 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

GENERIC FRAMEWORK

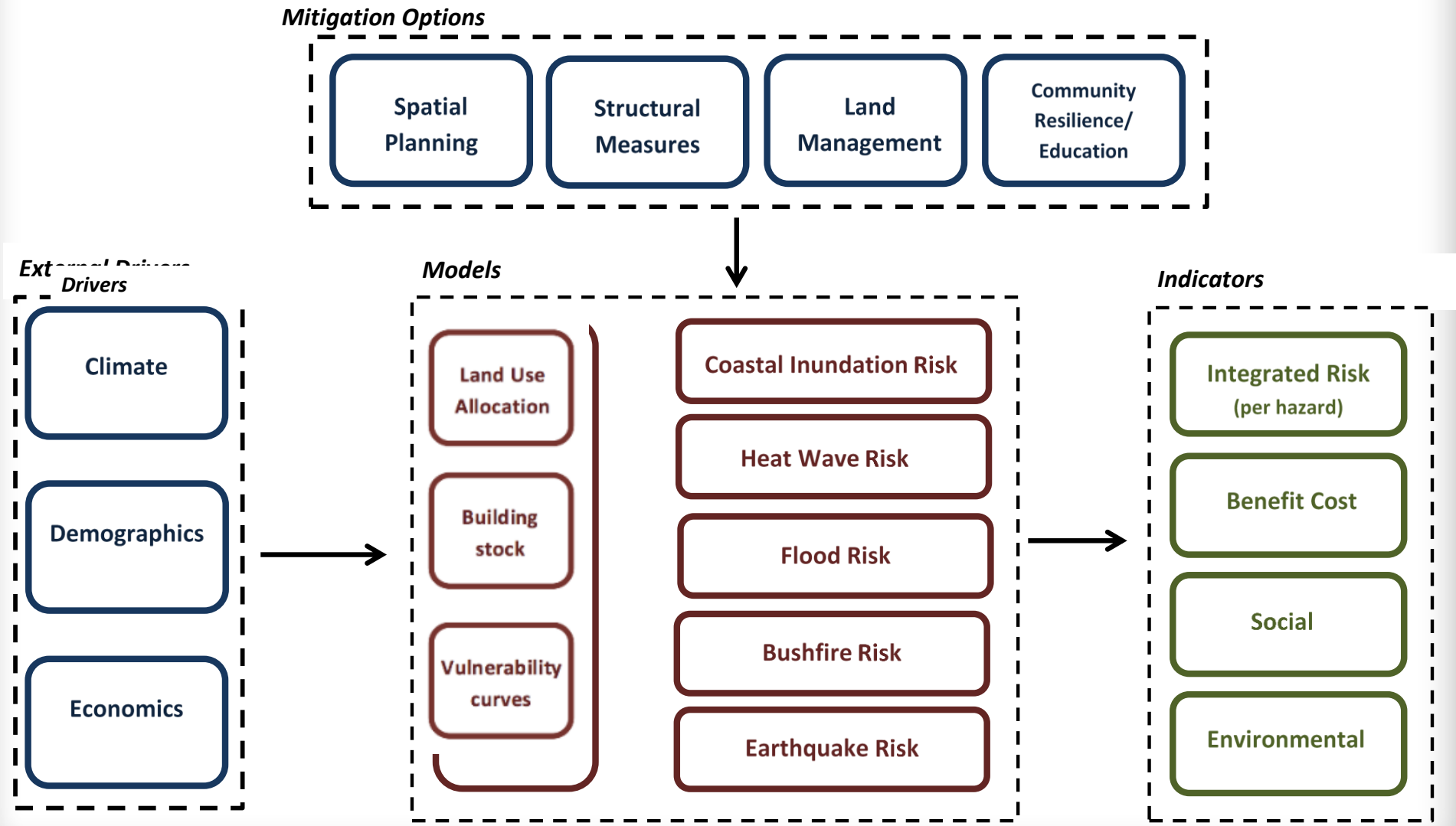
Conceptual Approach

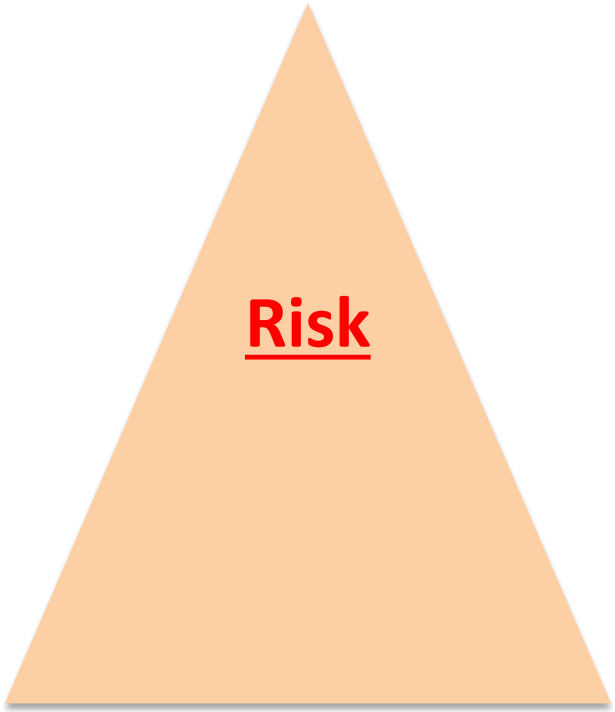
Modelling Approach

Software Framework

Case Study Development and Use

OVERALL STRUCTURE

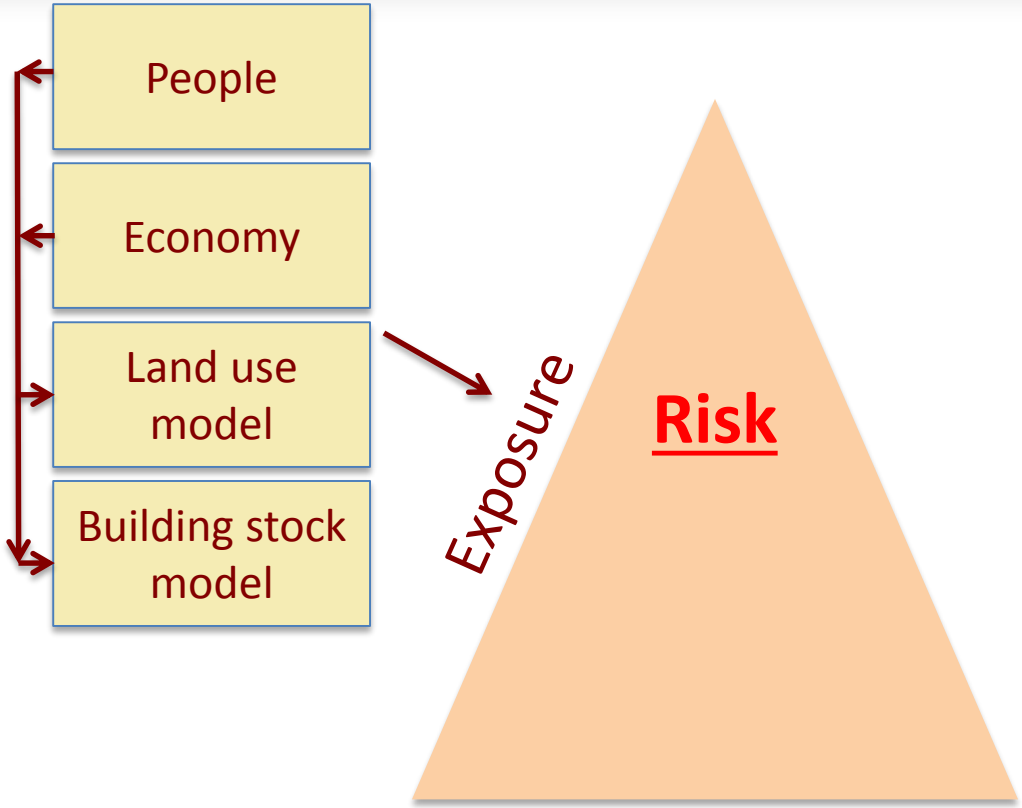


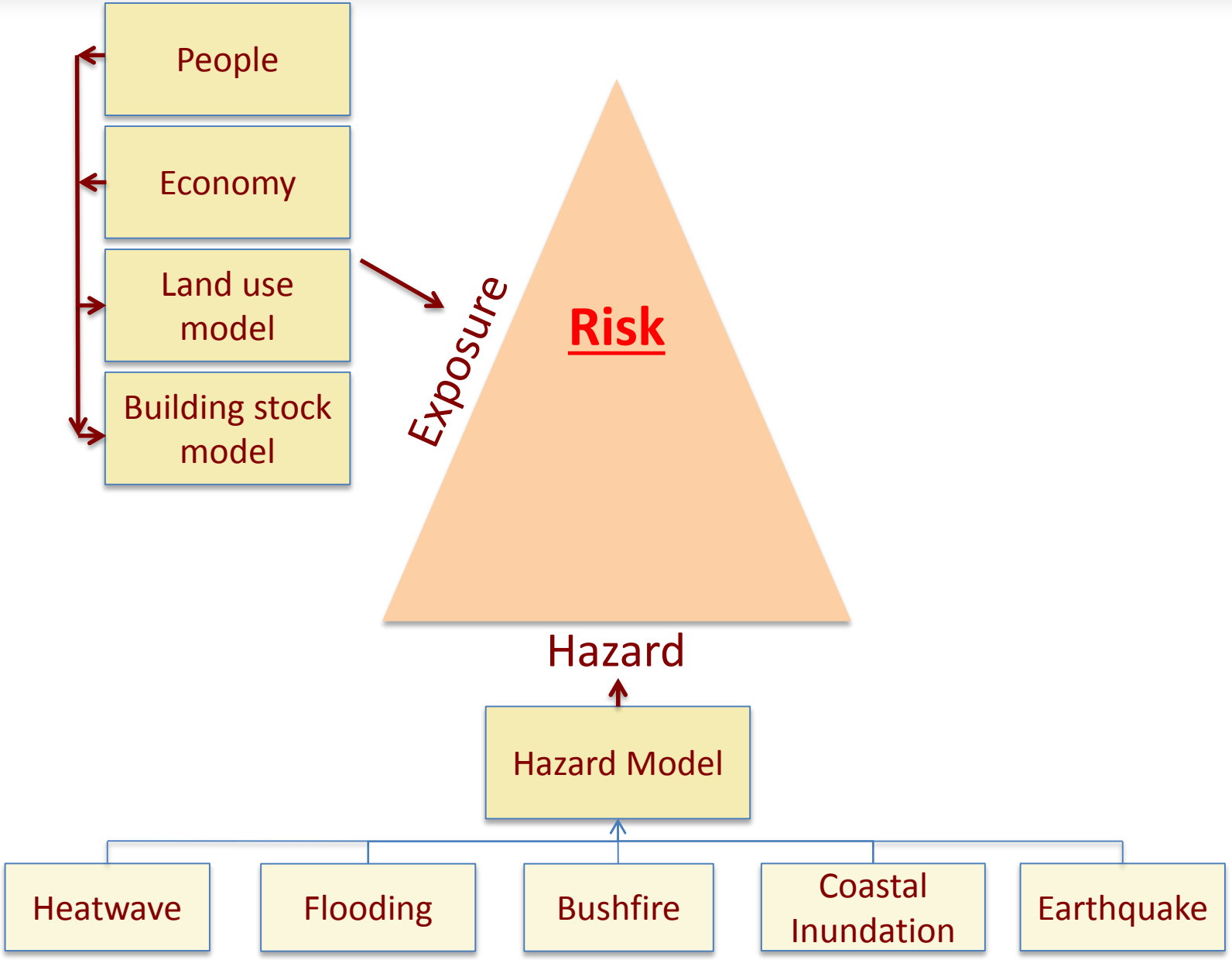

Risk

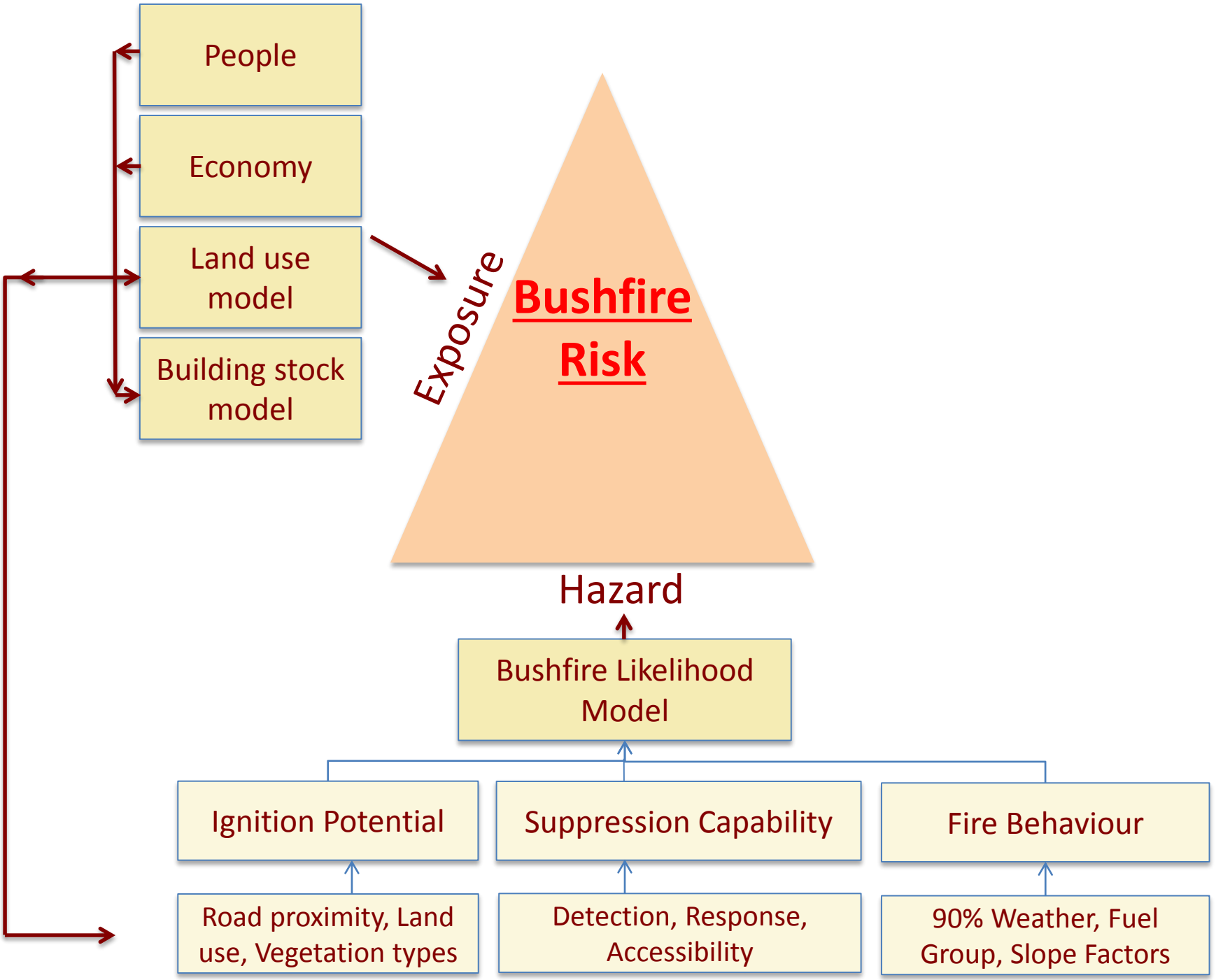
People

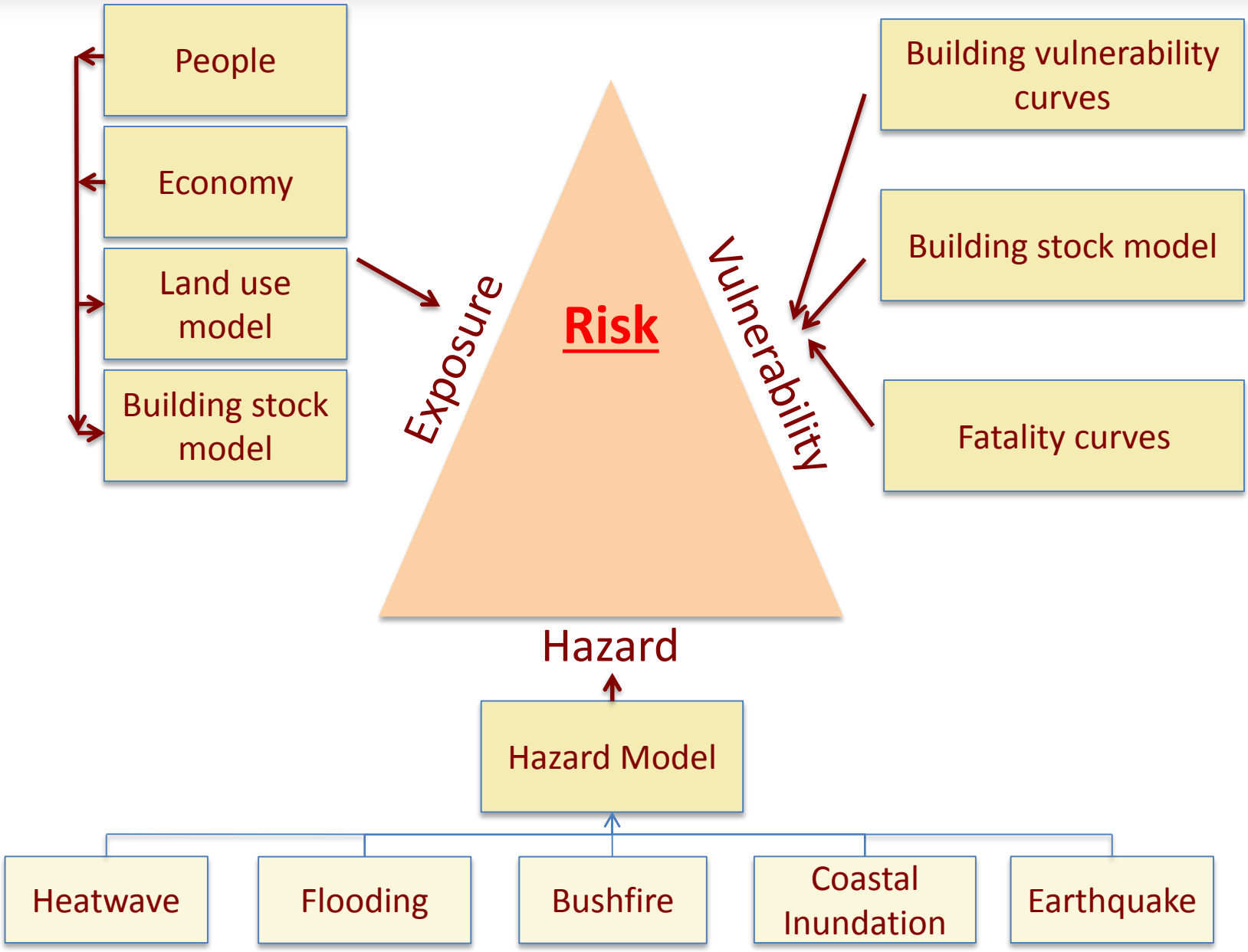
People

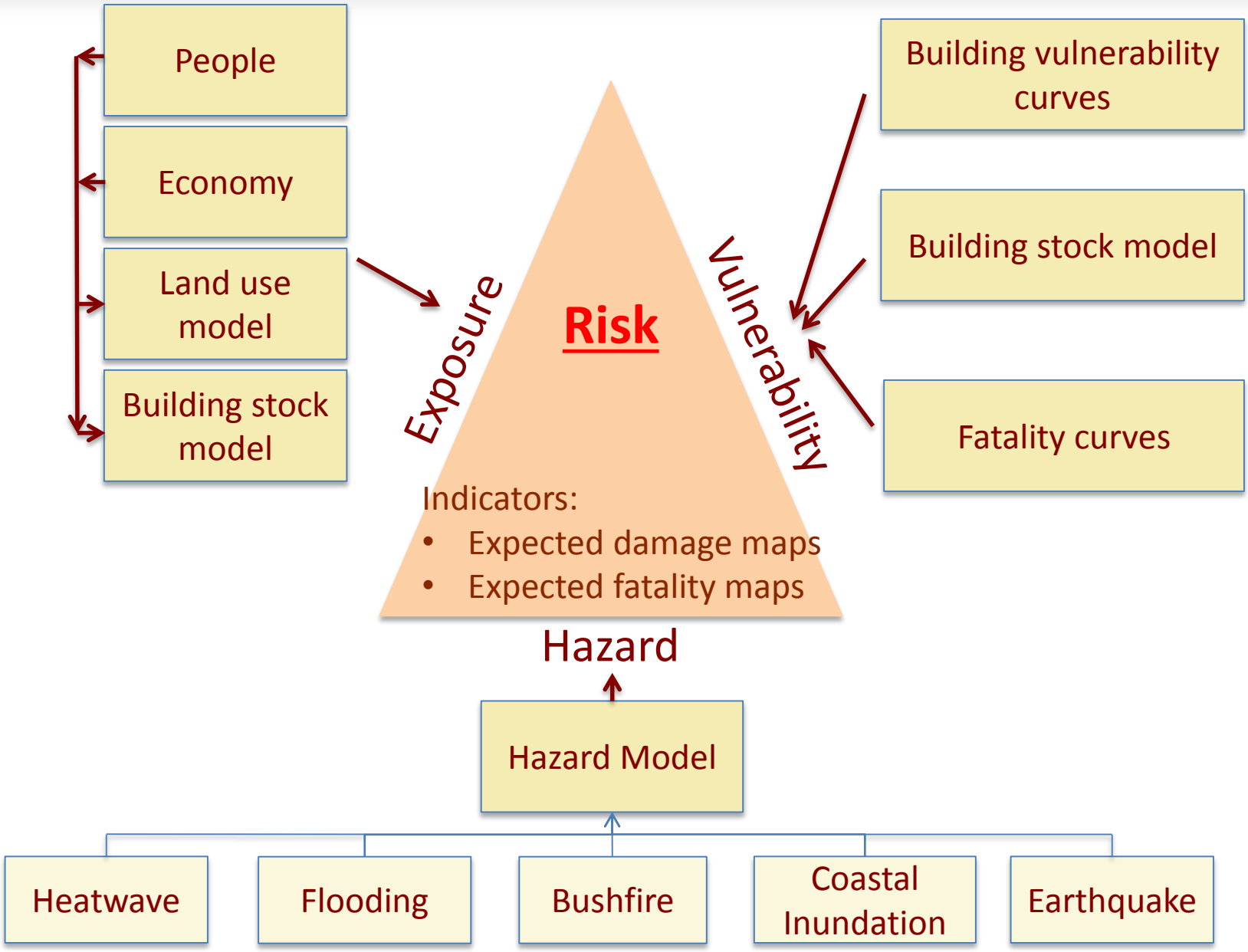
Economy


People
Economy
Land use model
Building stock model
Exposure
Risk


People
Economy
Land use model
Building stock model
Exposure
Risk
Hazard
Hazard Model
Heatwave
Flooding
Bushfire
Coastal Inundation
Earthquake


People
Economy
Land use model
Building stock model
Exposure
Bushfire Risk
Hazard
Bushfire Likelihood Model
Ignition Potential
Suppression Capability
Fire Behaviour
Road proximity, Land use, Vegetation types
Detection, Response, Accessibility
90% Weather, Fuel Group, Slope Factors


People
Economy
Land use model
Building stock model
Exposure
Risk
Vulnerability
Building vulnerability curves
Building stock model
Fatality curves
Hazard
Hazard Model
Heatwave
Flooding
Bushfire
Coastal Inundation
Earthquake


People
Economy
Land use model
Building stock model
Exposure
Risk
Vulnerability
Building vulnerability curves
Building stock model
Fatality curves
Indicators:
• Expected damage maps
• Expected fatality maps
Hazard
Hazard Model
Heatwave
Flooding
Bushfire
Coastal Inundation
Earthquake

GENERIC FRAMEWORK

Conceptual Approach

Modelling Approach

Software Framework

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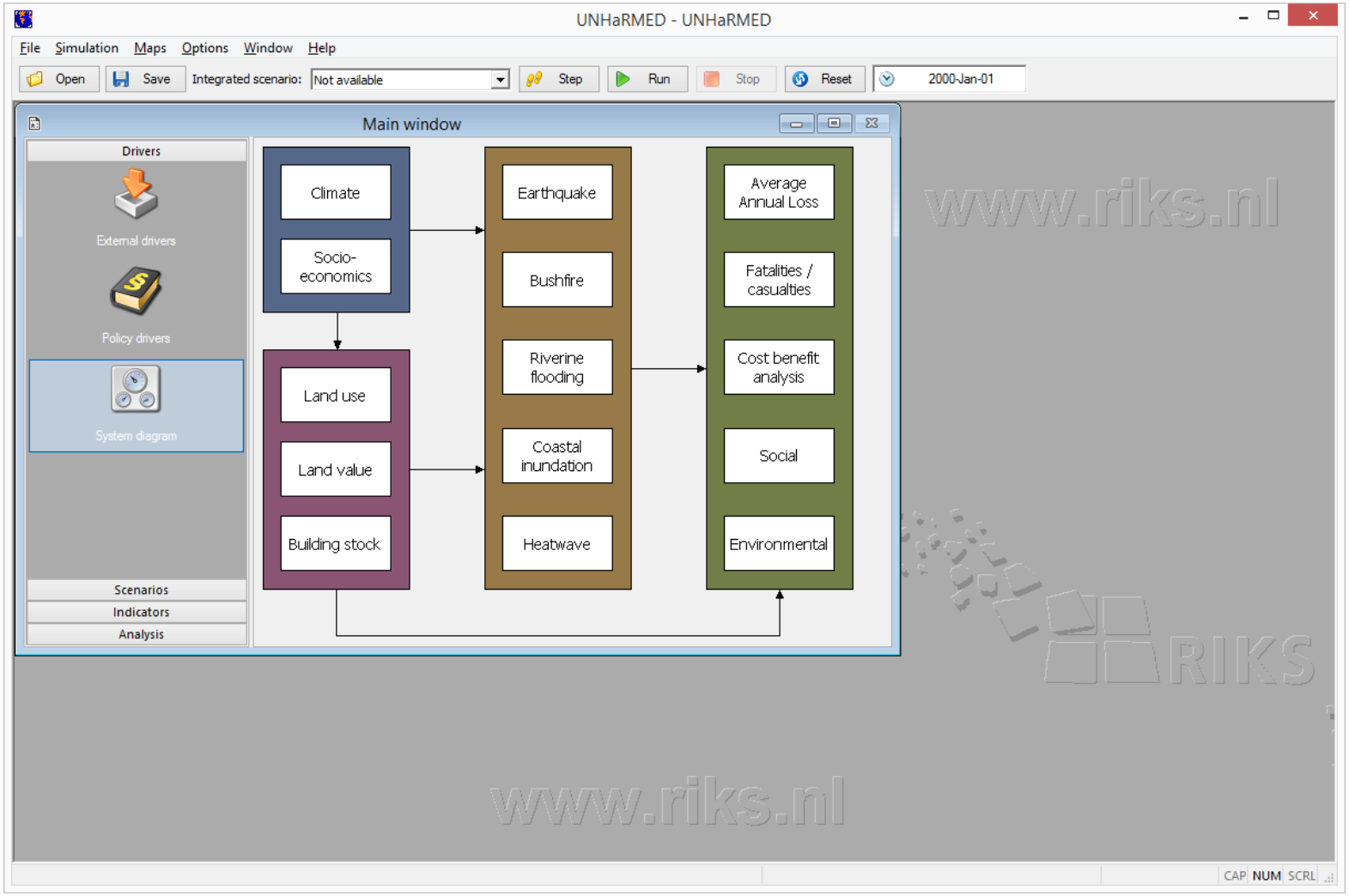
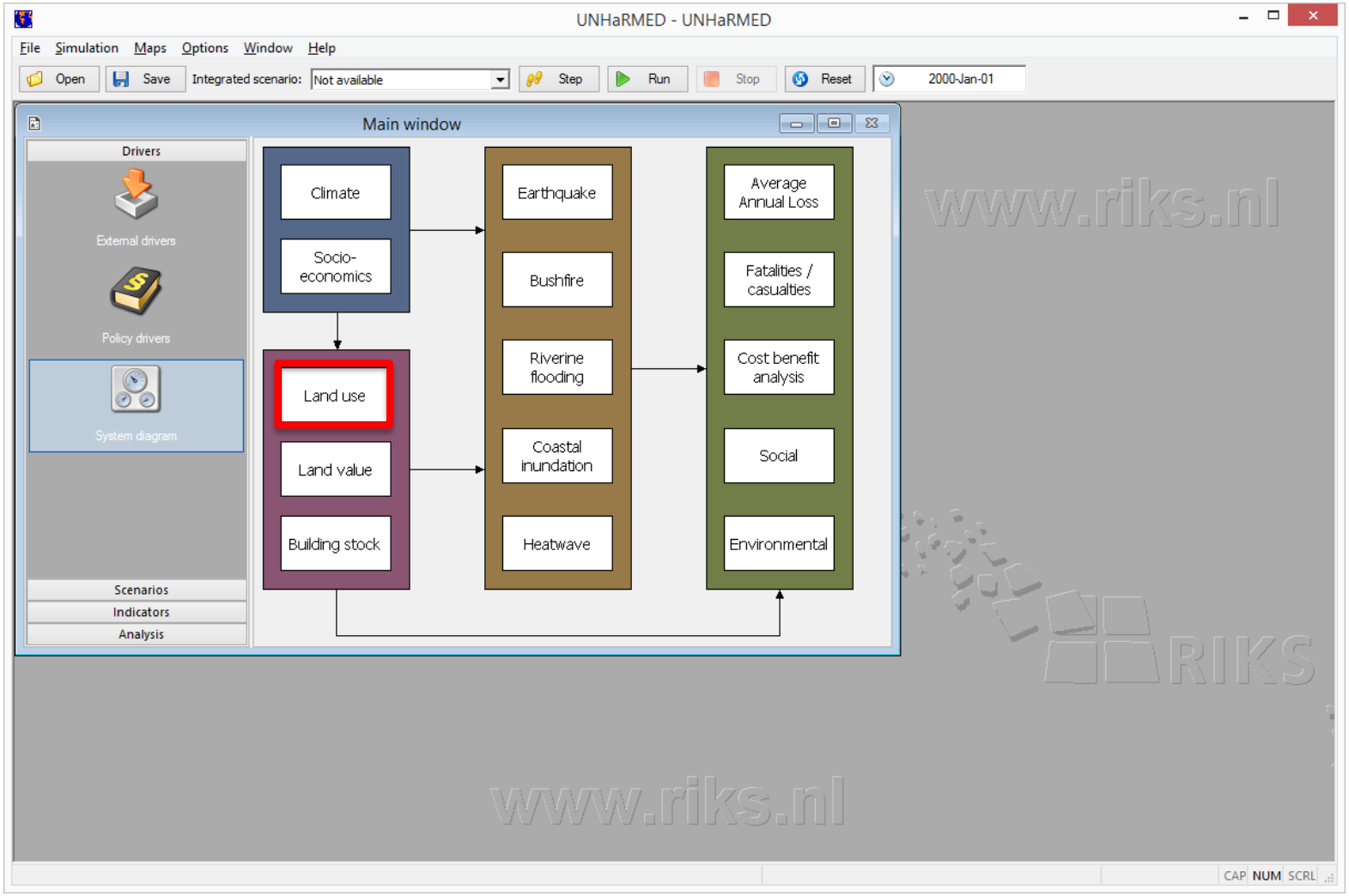
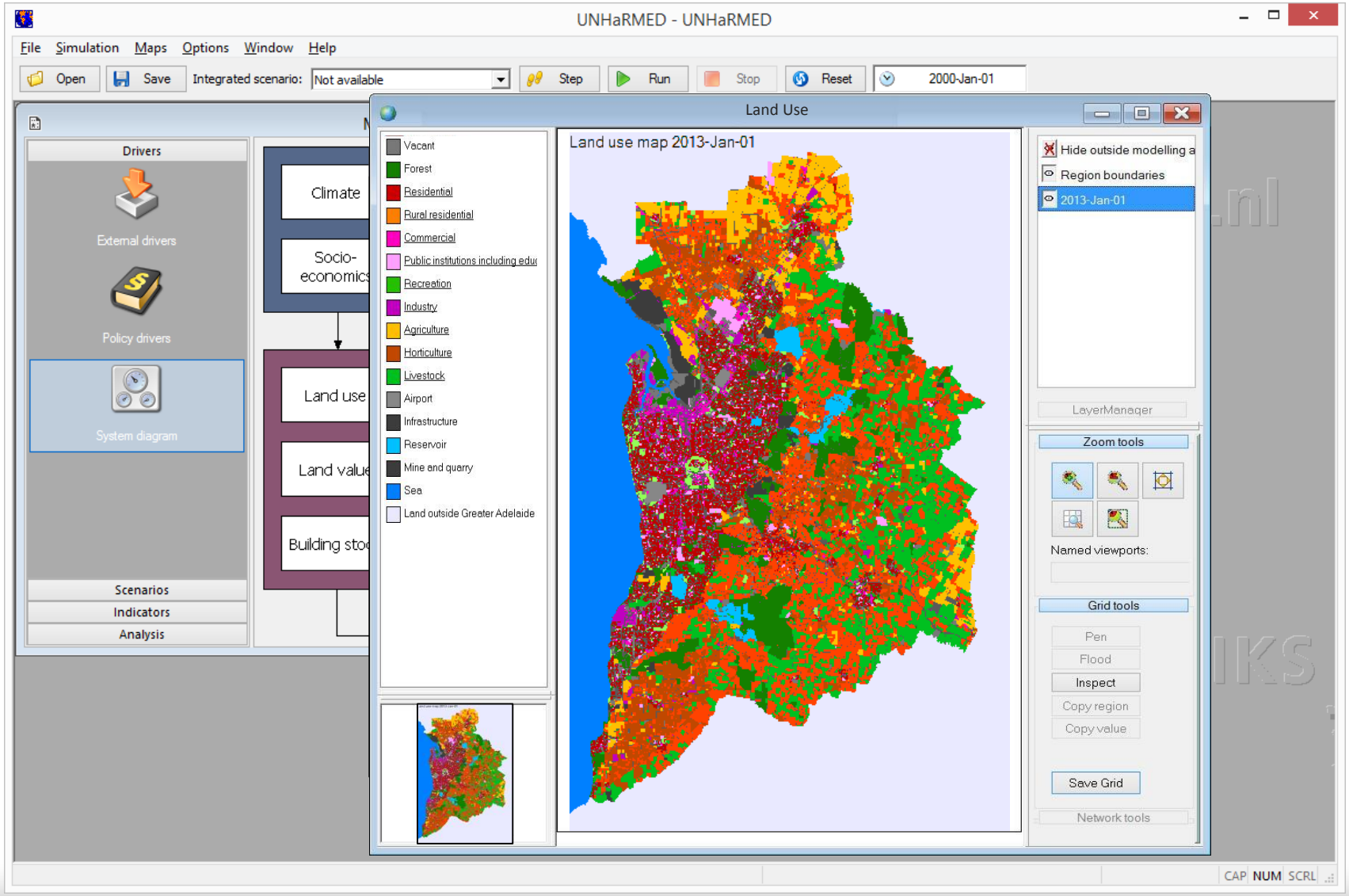
SYSTEM DIAGRAM



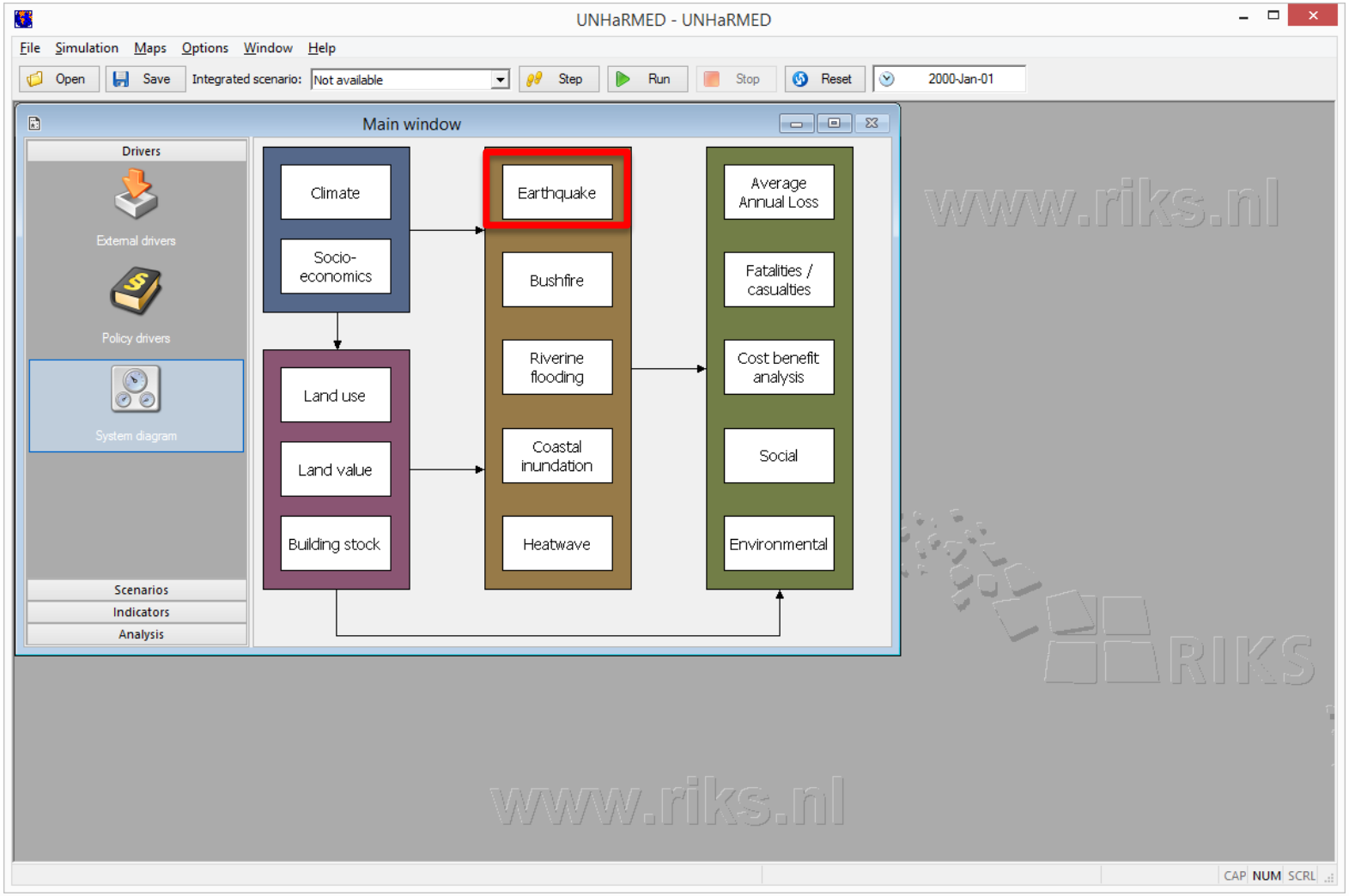
SYSTEM DIAGRAM



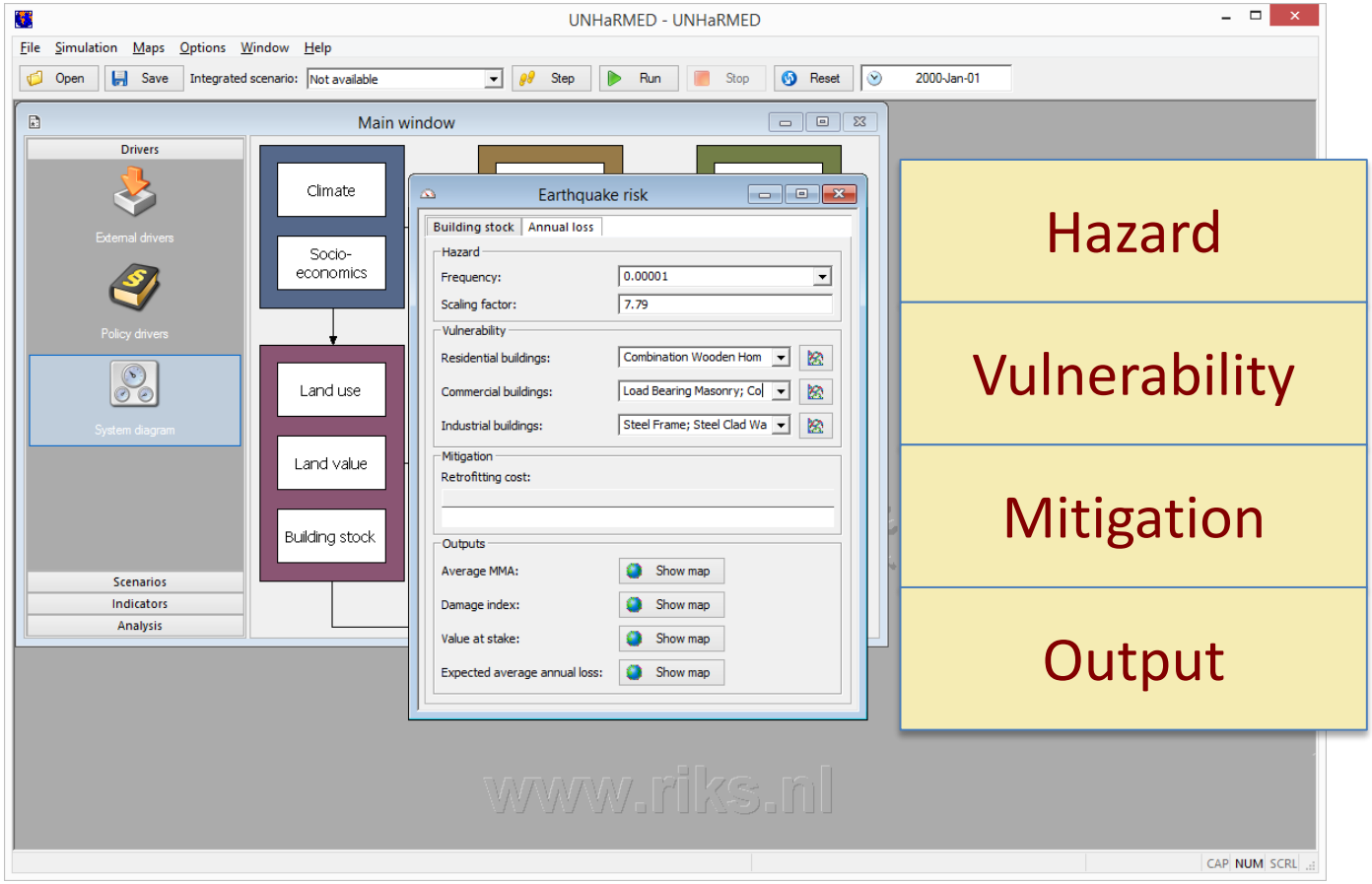
LANDUSE ALLOCATION

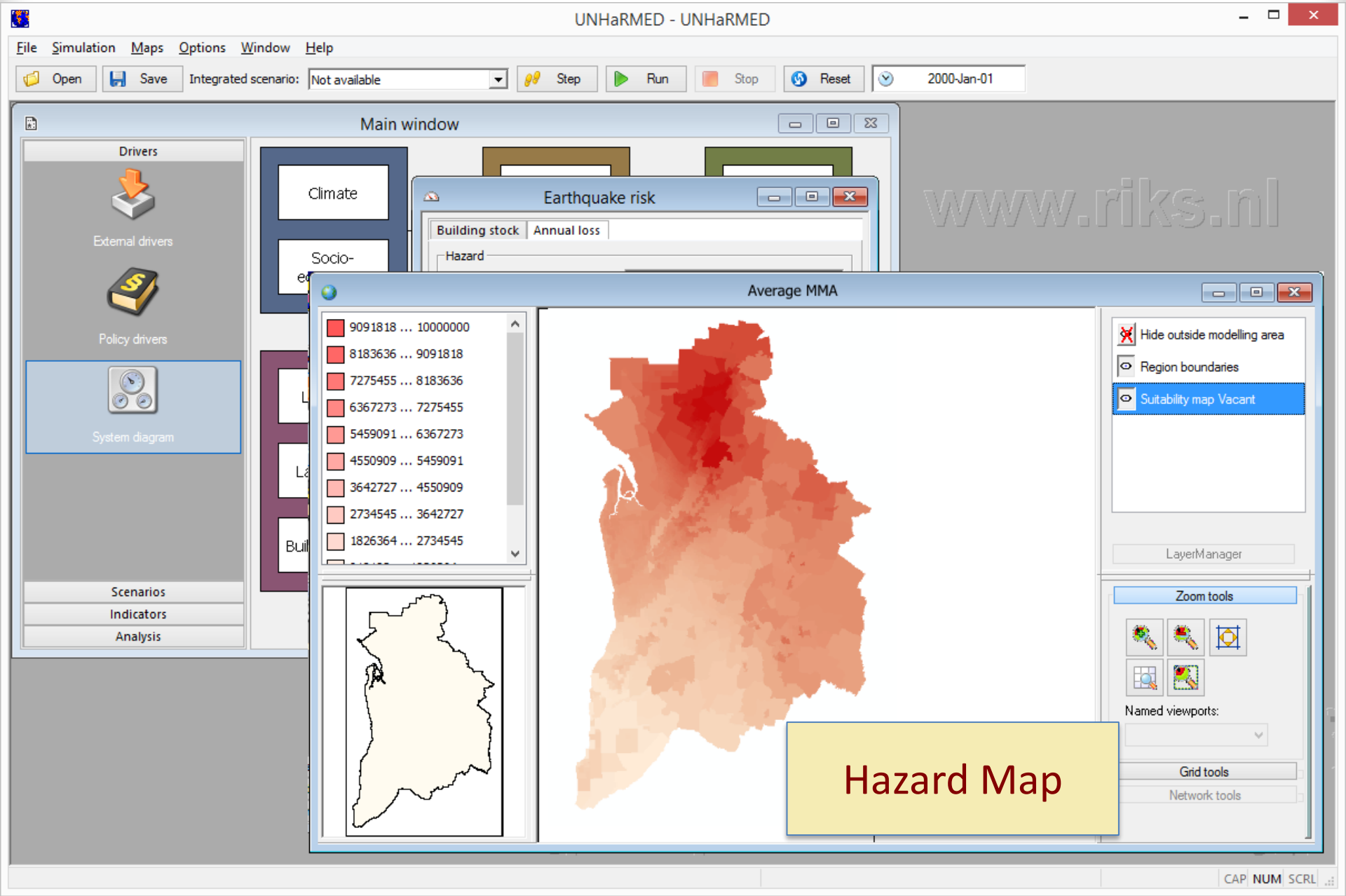


SYSTEM DIAGRAM

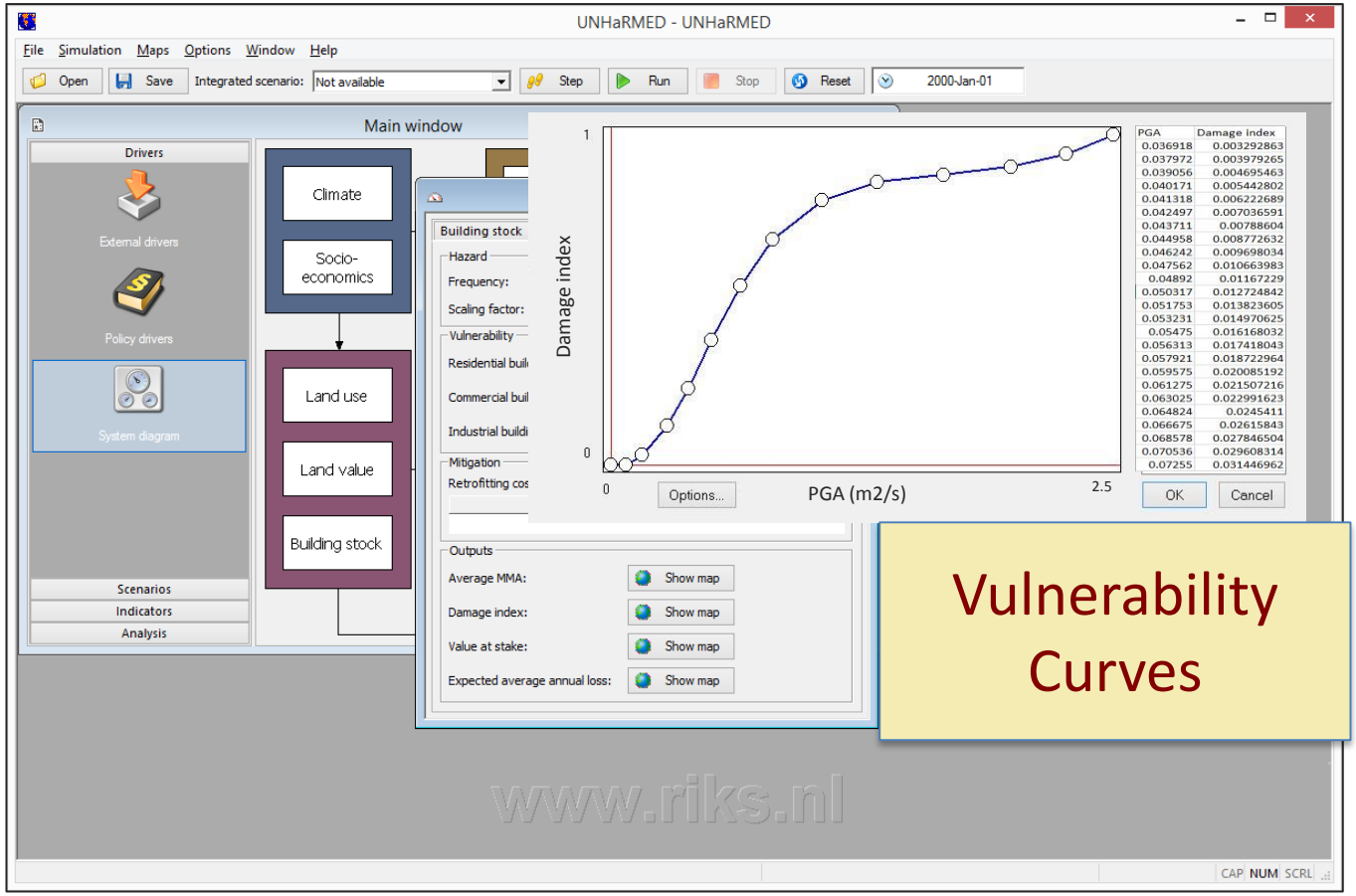


EARTHQUAKE

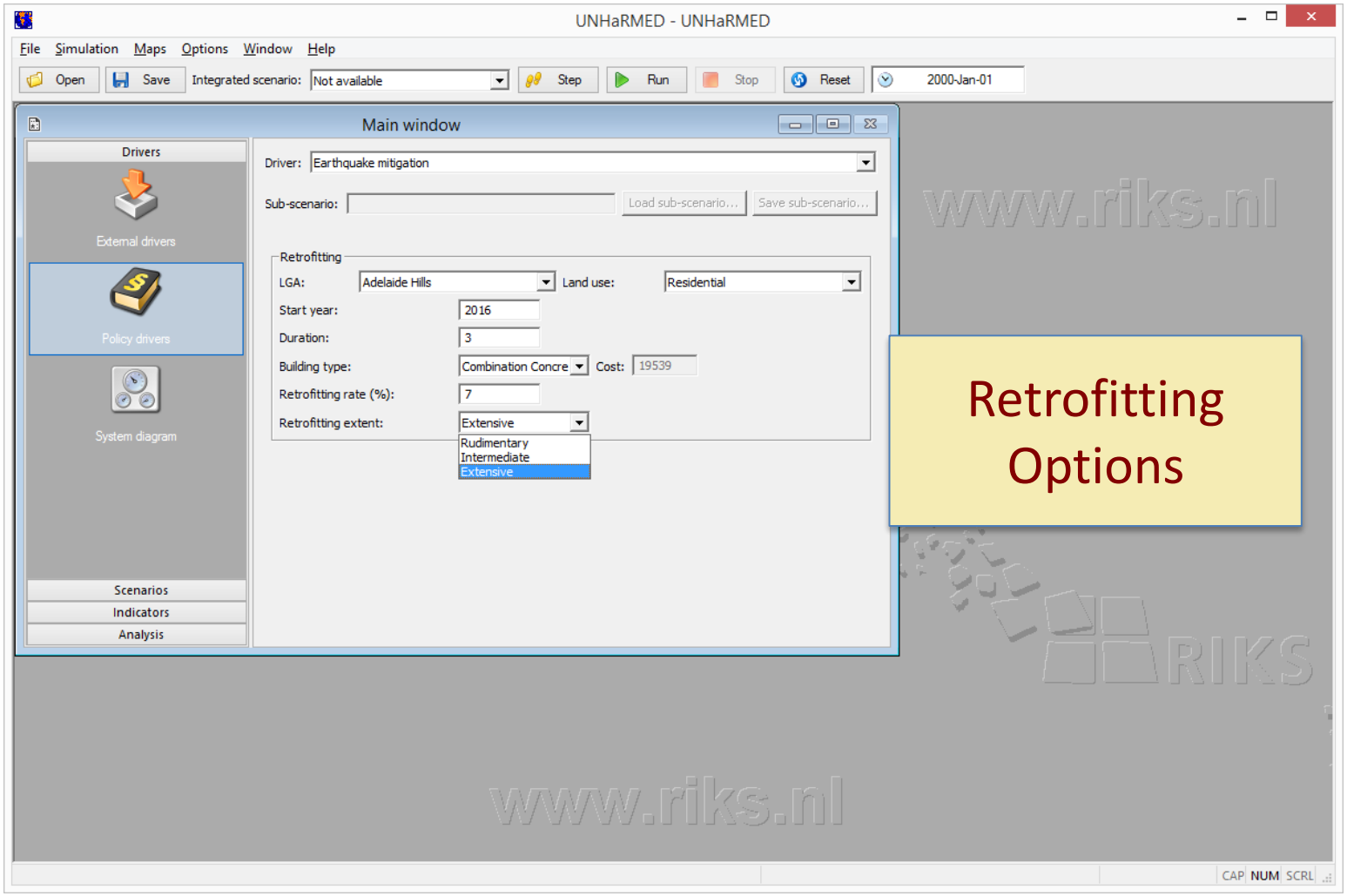

UNHaRMED - UNHaRMED
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Main window
Drivers
External drivers
Policy drivers
System diagram
Scenarios
Indicators
Analysis
Climate
Socio-economics
Land use
Land value
Building stock
Earthquake risk
Building stock Annual loss
Hazard
Frequency: 0.00001
Scaling factor: 7.79
Vulnerability
Residential buildings: Combination Wooden Hom
Commercial buildings: Load Bearing Masonry; Col
Industrial buildings: Steel Frame; Steel Clad Wa
Mitigation
Retrofitting cost:
Outputs
Average MMA: Show map
Damage index: Show map
Value at stake: Show map
Expected average annual loss: Show map
www.riks.nl
CAP NUM SCRL
Hazard
Vulnerability
Mitigation
Output


UNHaRMED - UNHaRMED
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Main window
Drivers
External drivers
Policy drivers
System diagram
Scenarios
Indicators
Analysis
Climate
Socio-
Earthquake risk
Building stock
Annual loss
Hazard
www.riks.nl
Average MMA
9091818 ... 10000000
8183636 ... 9091818
7275455 ... 8183636
6367273 ... 7275455
5459091 ... 6367273
4550909 ... 5459091
3642727 ... 4550909
2734545 ... 3642727
1826364 ... 2734545
Hide outside modelling area
Region boundaries
Suitability map Vacant
LayerManager
Zoom tools
Named viewports:
Grid tools
Network tools
Hazard Map
CAP NUM SCRL

EARTHQUAKE


UNHaRMED - UNHaRMED
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Main window
Drivers
External drivers
Policy drivers
System diagram
Scenarios
Indicators
Analysis
Climate
Socio-economics
Land use
Land value
Building stock
Building stock
Hazard
Frequency:
Scaling factor:
Vulnerability
Residential buil
Commercial buil
Industrial buildi
Mitigation
Retrofitting cos
Outputs
Average MMA: Show map
Damage index: Show map
Value at stake: Show map
Expected average annual loss: Show map
Damage index
1
0
0
2.5
PGA (m2/s)
Options...
OK
Cancel
PGA Damage index
0.036918 0.003292863
0.037972 0.003979265
0.039056 0.004695463
0.040171 0.005442802
0.041318 0.006222689
0.042497 0.007036591
0.043711 0.00788604
0.044958 0.008772632
0.046242 0.009698034
0.047562 0.010663983
0.04892 0.01167229
0.050317 0.012724842
0.051753 0.013823605
0.053231 0.014970625
0.05475 0.016168032
0.056313 0.017418043
0.057921 0.018722964
0.059575 0.020085192
0.061275 0.021507216
0.063025 0.022991623
0.064824 0.0245411
0.066675 0.02615843
0.068578 0.027846504
0.070536 0.029608314
0.07255 0.031446962
Vulnerability Curves
www.riks.nl
CAP NUM SCRL

EARTHQUAKE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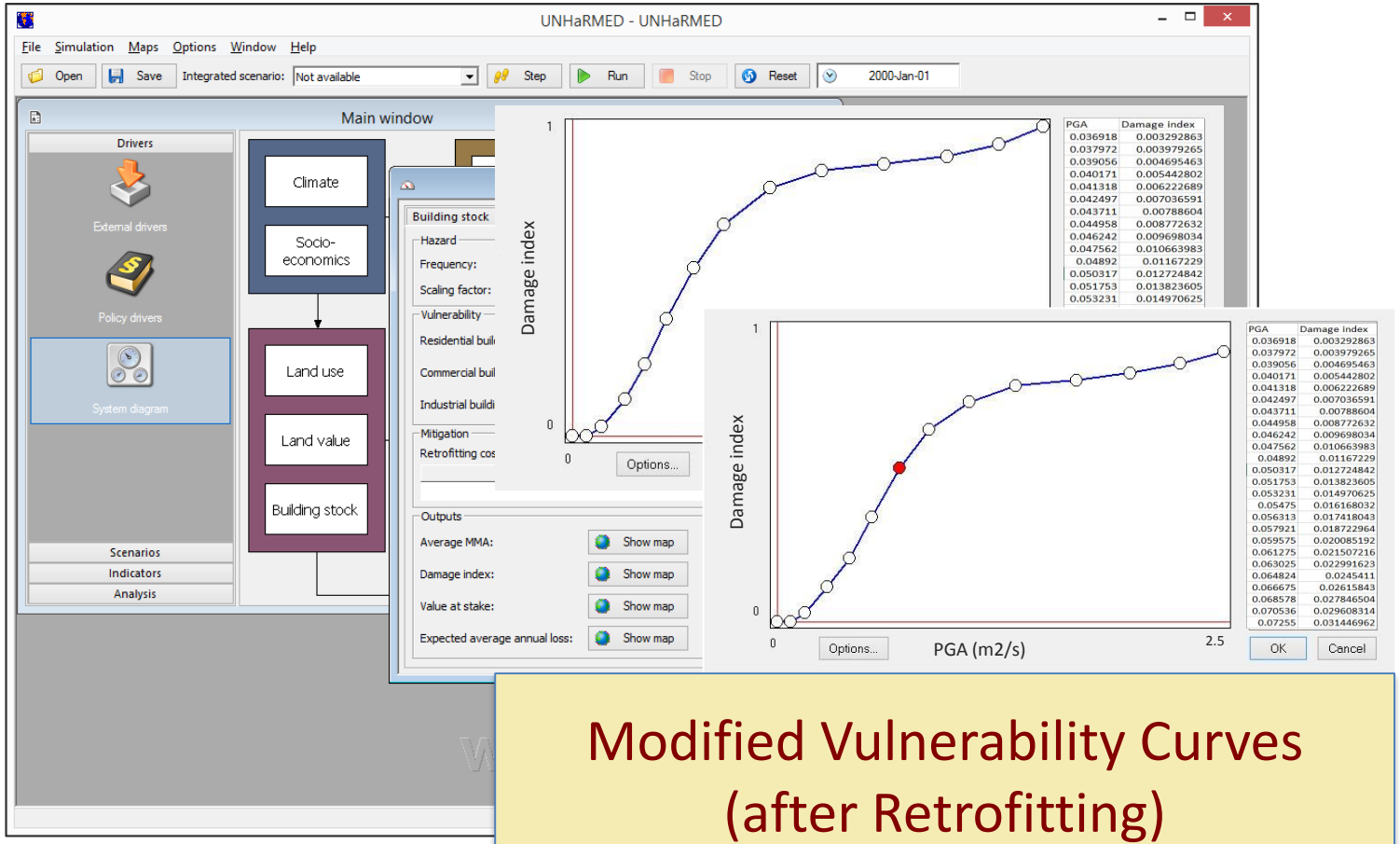
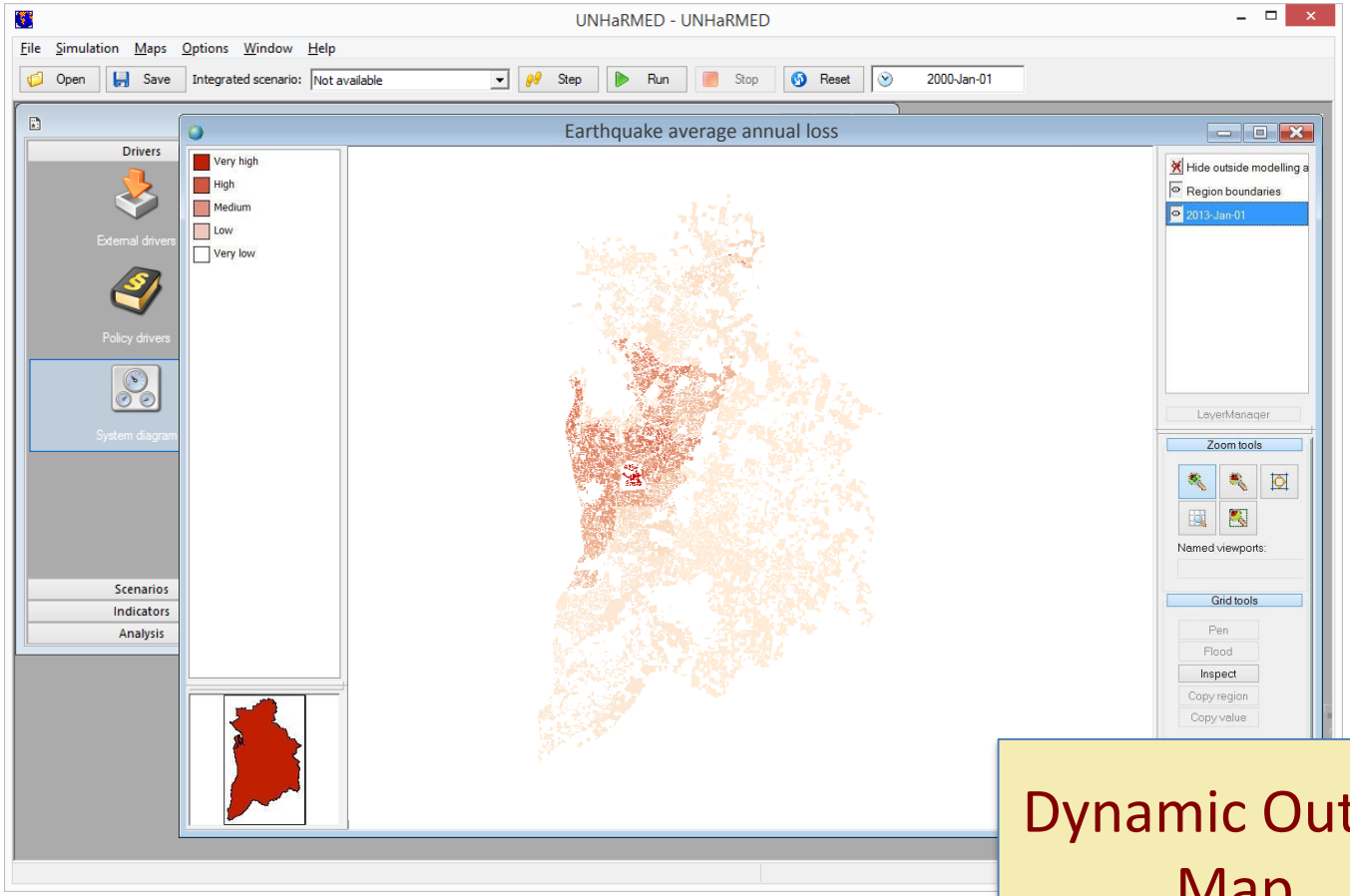
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Main window
Drivers
External drivers
Policy drivers
System diagram
Scenarios
Indicators
Analysis
Driver: Earthquake mitigation
Sub-scenario: Load sub-scenario... Save sub-scenario...
Retrofitting
LGA: Adelaide Hills Land use: Residential
Start year: 2016
Duration: 3
Building type: Combination Concre Cost: 19539
Retrofitting rate (%): 7
Retrofitting extent: Extensive
Rudimentary
Intermediate
Extensive
Retrofitting Options
www.riks.nl
RIKS
www.riks.nl
CAP NUM SCRL

EARTHQUAKE

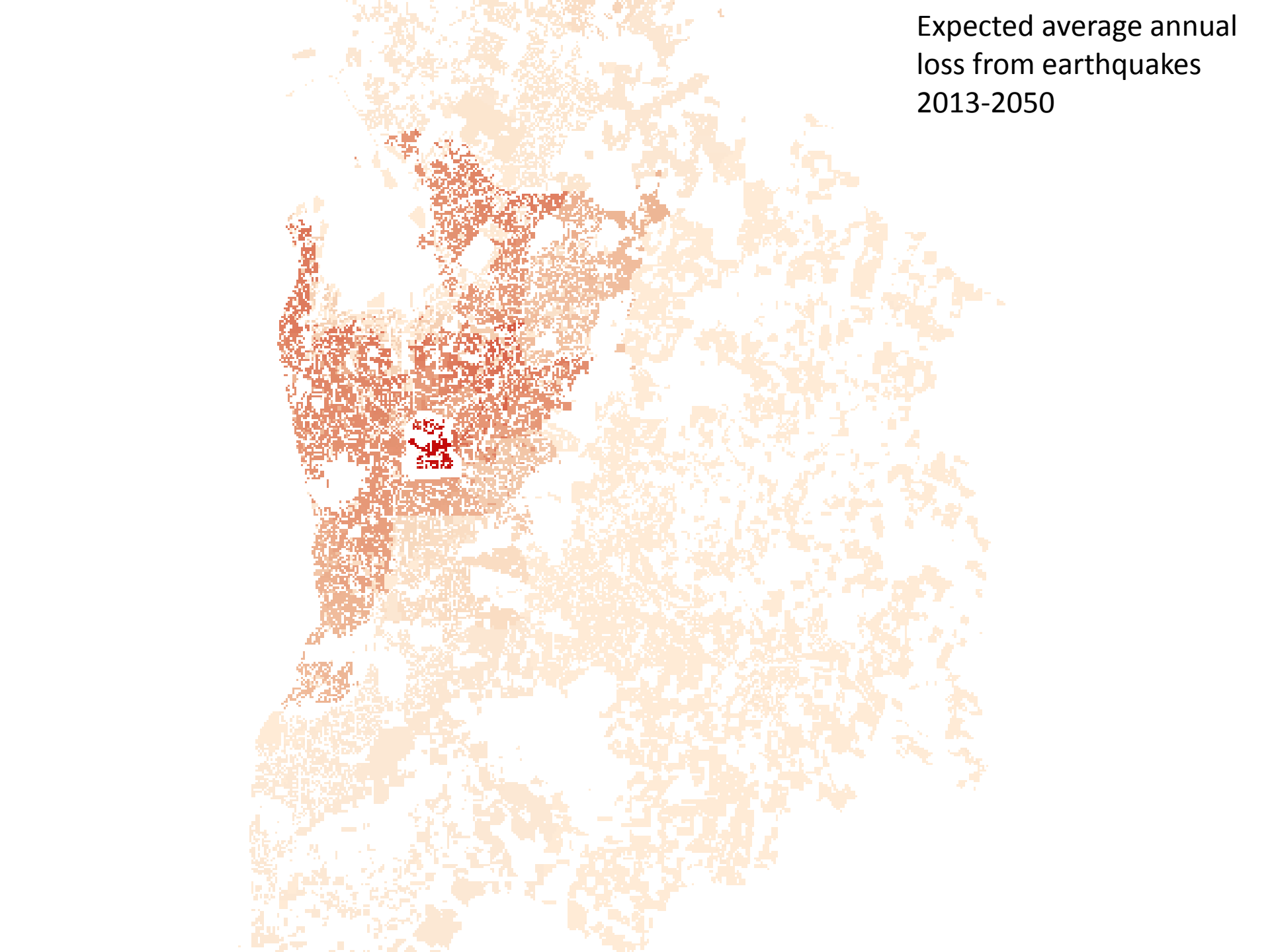


Modified Vulnerability Curves (after Retrofitting)

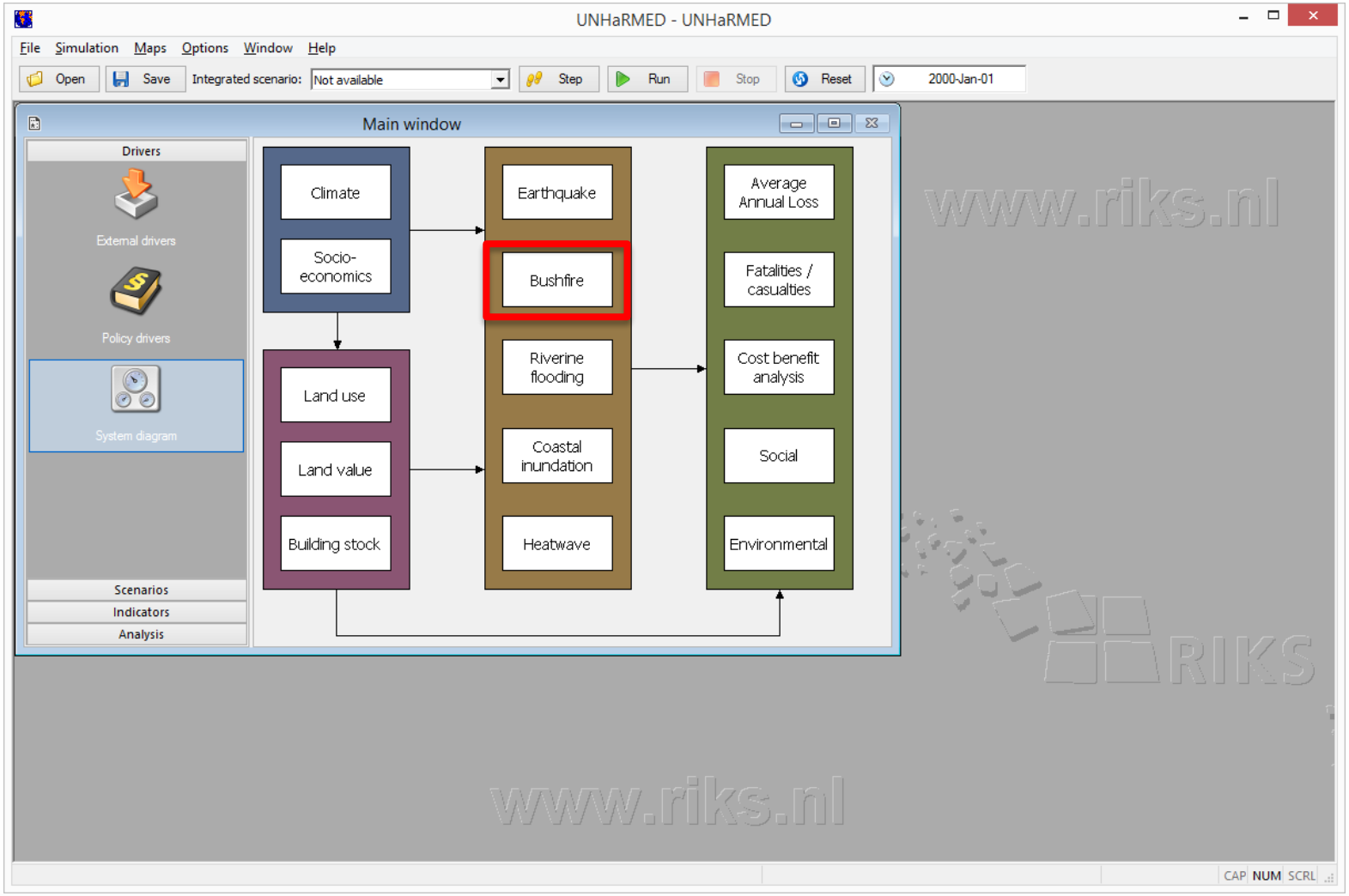
EARTHQUAKE



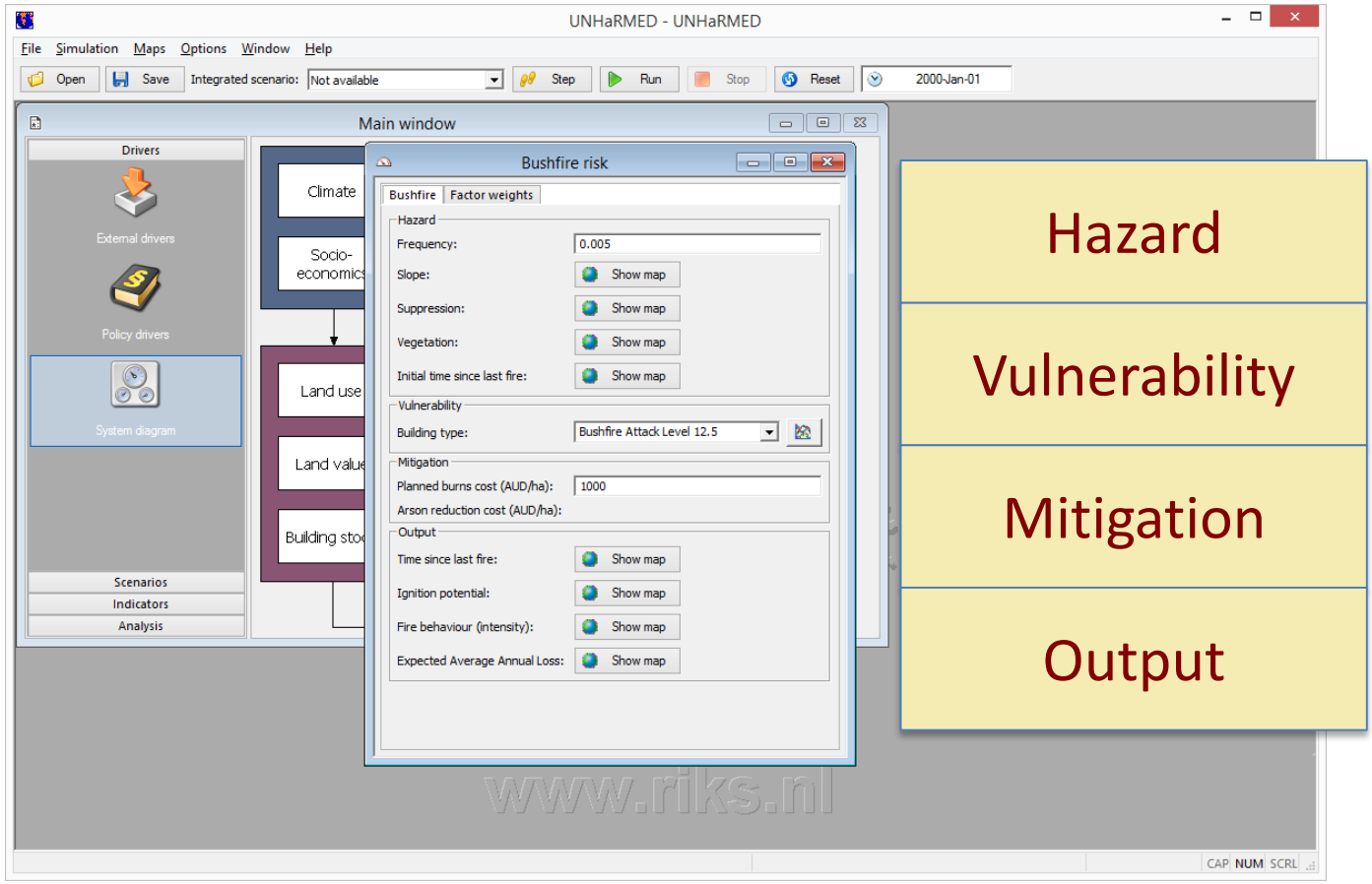
Dynamic Output Map


Expected average annual
loss from earthquakes
2013-2050

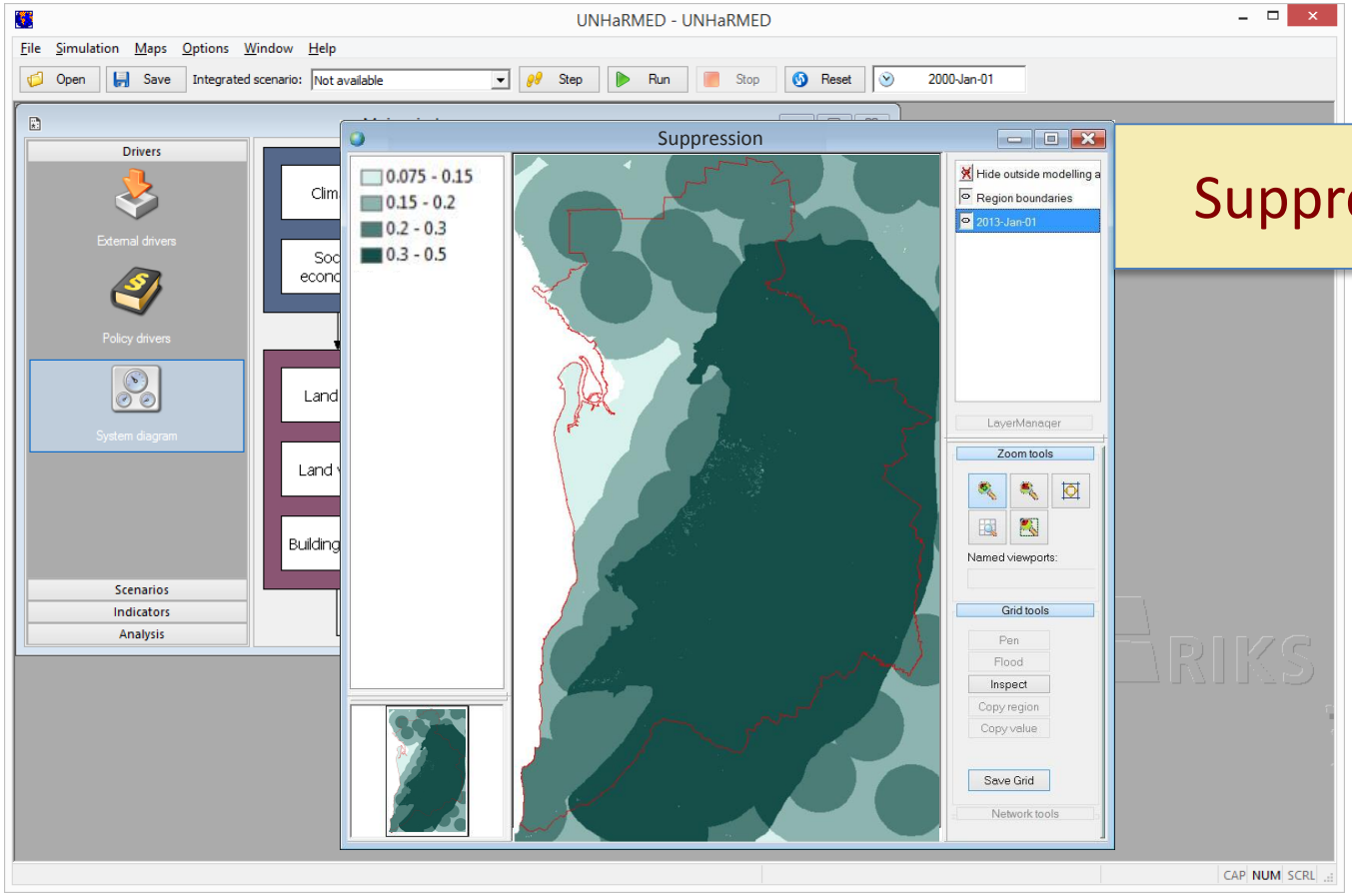
SYSTEM DIAGRAM



BUSHFIRE

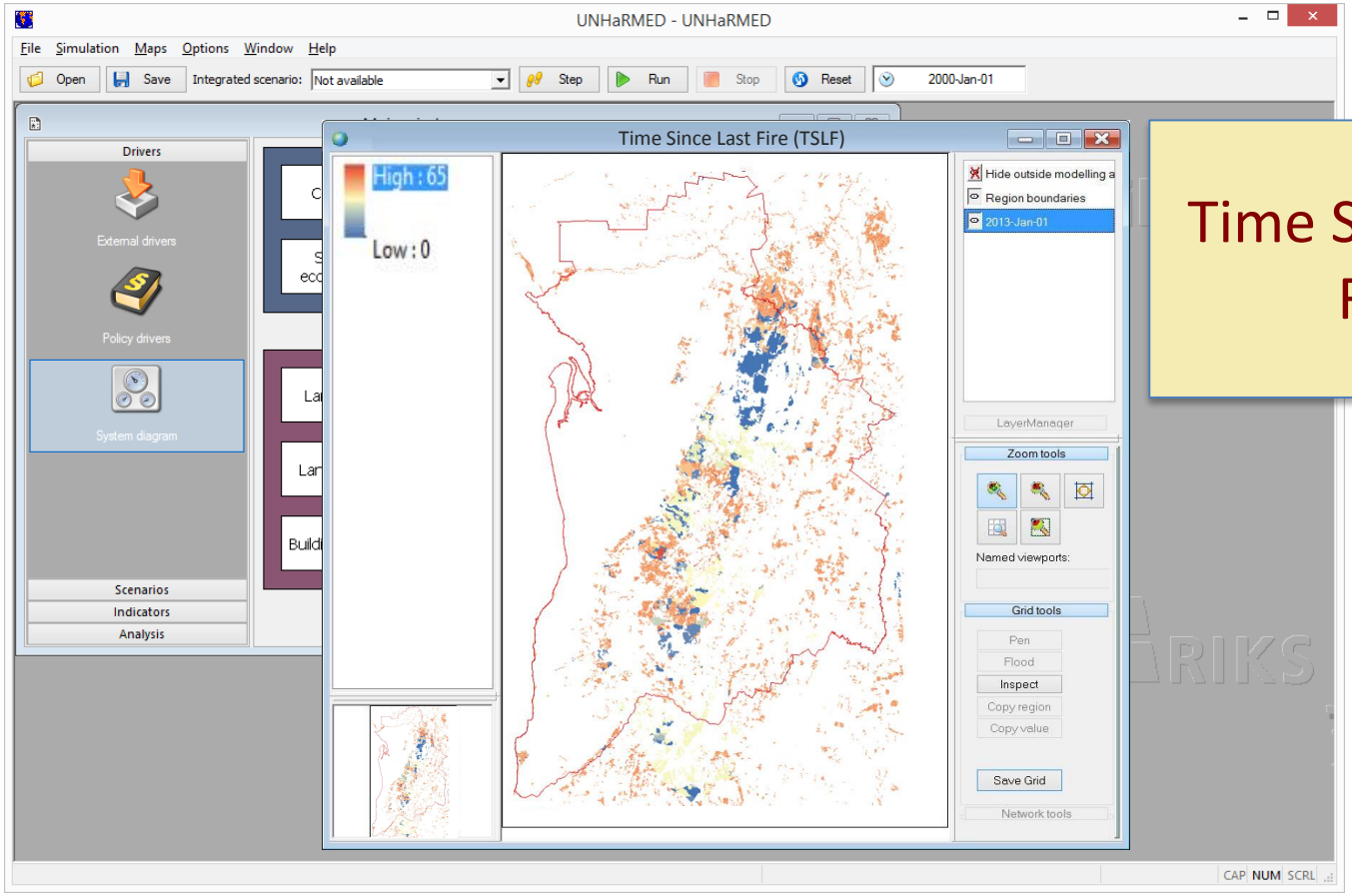

UNHaRMED - UNHaRMED
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Main window
Drivers
External drivers
Policy drivers
System diagram
Scenarios
Indicators
Analysis
Climate
Socio-economics
Land use
Land value
Building stoc
Bushfire risk
Bushfire Factor weights
Hazard
Frequency: 0.005
Slope: Show map
Suppression: Show map
Vegetation: Show map
Initial time since last fire: Show map
Vulnerability
Building type: Bushfire Attack Level 12.5
Mitigation
Planned burns cost (AUD/ha): 1000
Arson reduction cost (AUD/ha):
Output
Time since last fire: Show map
Ignition potential: Show map
Fire behaviour (intensity): Show map
Expected Average Annual Loss: Show map
www.riks.nl
CAP NUM SCRL
Hazard
Vulnerability
Mitigation
Output

BUSHFIRE



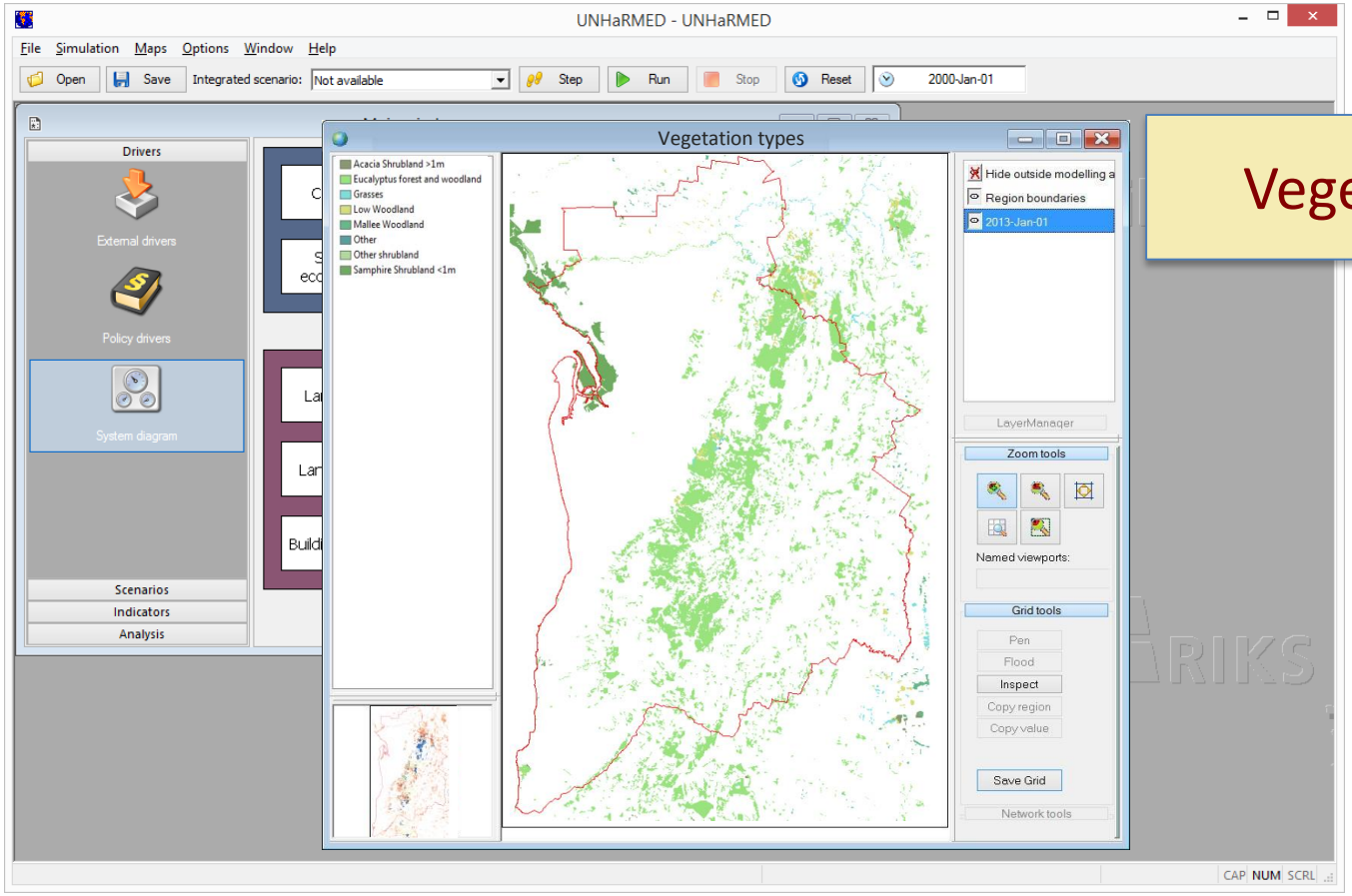
Suppression

BUSHFIRE



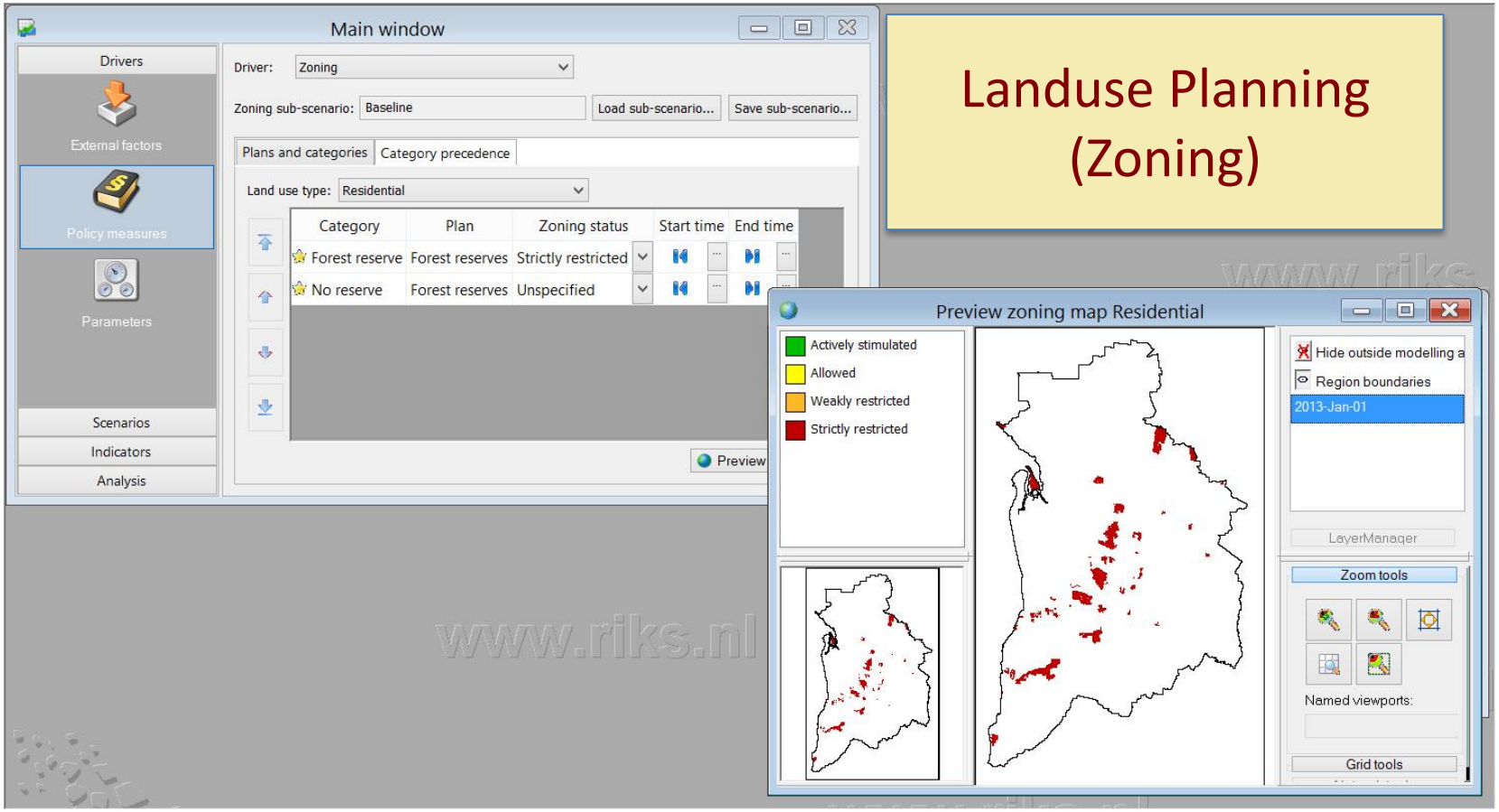
Time Since Last Fire

BUSHFIRE

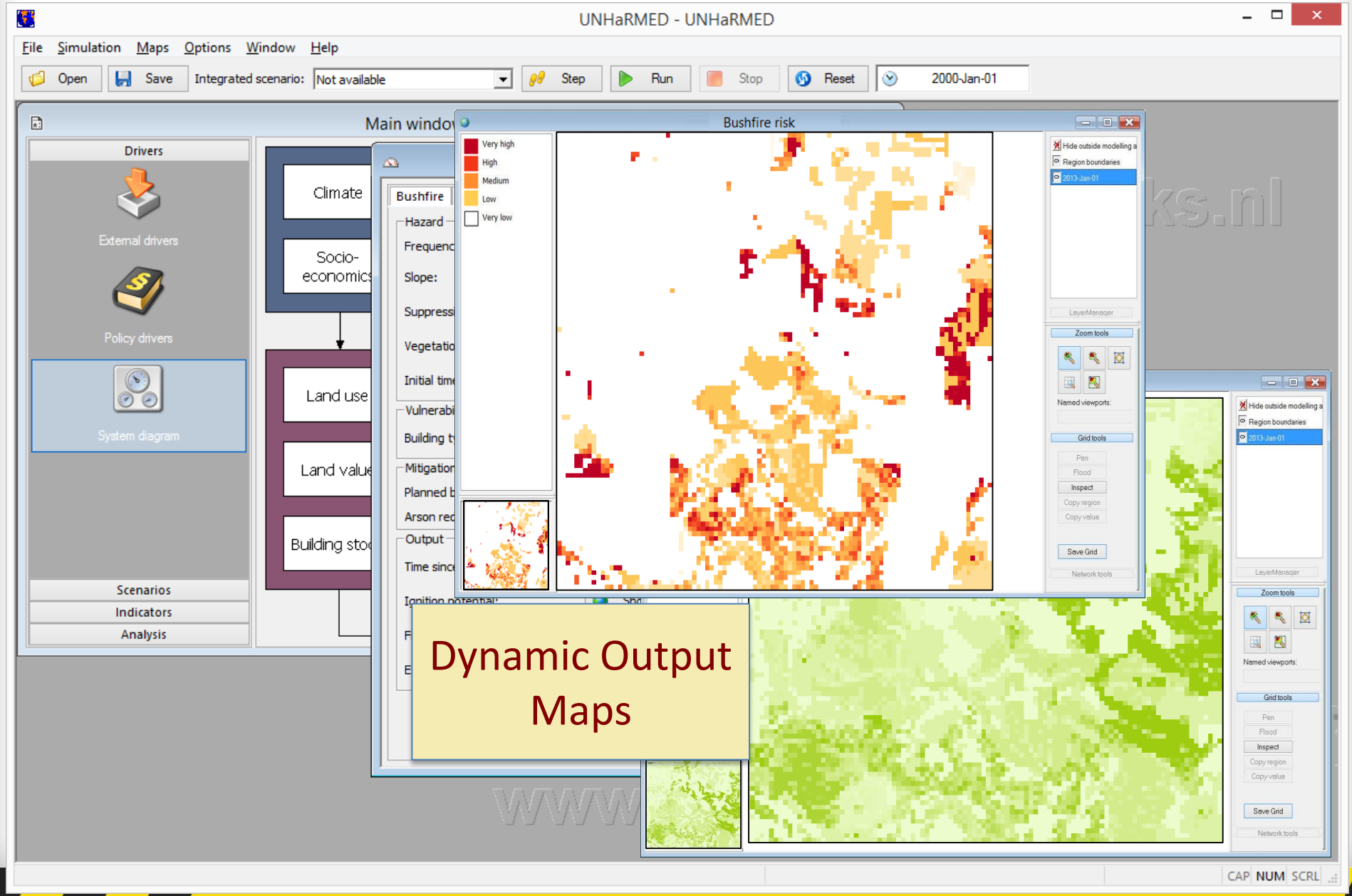


Vegetation

BUSHFIRE


Main window
Drivers
External factors
Policy measures
Parameters
Scenarios
Indicators
Analysis
Driver: Zoning
Zoning sub-scenario: Baseline
Load sub-scenario...
Save sub-scenario...
Plans and categories
Category precedence
Land use type: Residential
Category
Plan
Zoning status
Start time
End time
Forest reserve
Forest reserves
Strictly restricted
No reserve
Forest reserves
Unspecified
Preview
Landuse Planning (Zoning)
Preview zoning map Residential
Actively stimulated
Allowed
Weakly restricted
Strictly restricted
Hide outside modelling a
Region boundaries
2013-Jan-01
LayerManager
Zoom tools
Named viewports:
Grid tools
www.riks.nl

BUSHFIRE


UNHaRMED - UNHaRMED
File Simulation Maps Options Window Help
Open Save Integrated scenario: Not available Step Run Stop Reset 2000-Jan-01
Drivers
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Analysis
Climate
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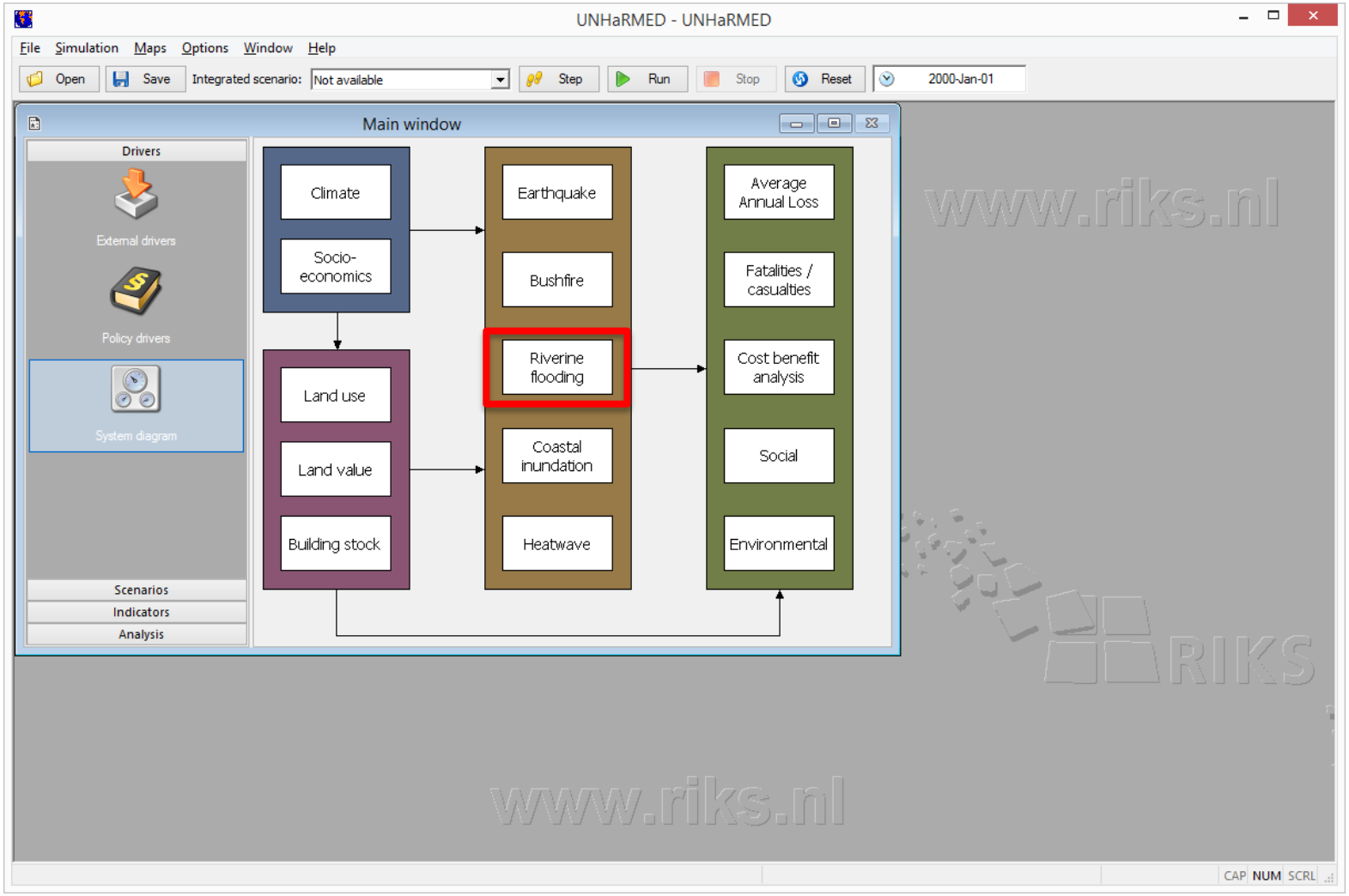
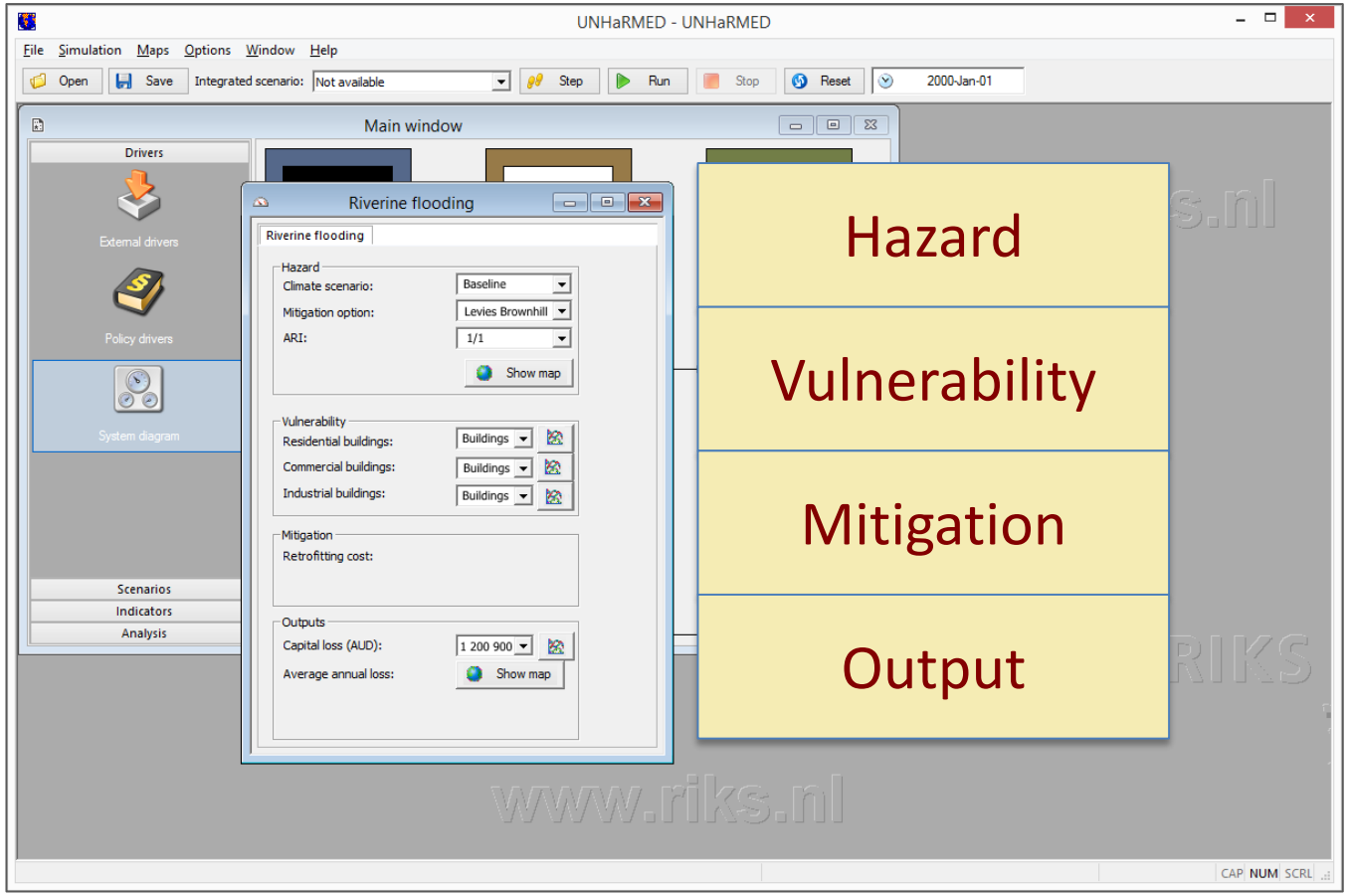
Land use
Land value
Building stock
Bushfire
Hazard
Frequenc
Slope:
Suppressi
Vegetatio
Initial time
Vulnerabi
Building t
Mitigation
Planned b
Arson rec
Output
Time since
Ignition potential:
Bushfire risk
Very high
High
Medium
Low
Very low
Hide outside modelling a
Region boundaries
2013-Jan-01
LayerManager
Zoom tools
Named viewports:
Grid tools
Pen
Flood
Inspect
Copy region
Copy value
Save Grid
Network tools
Dynamic Output Maps
CAP NUM SCRL

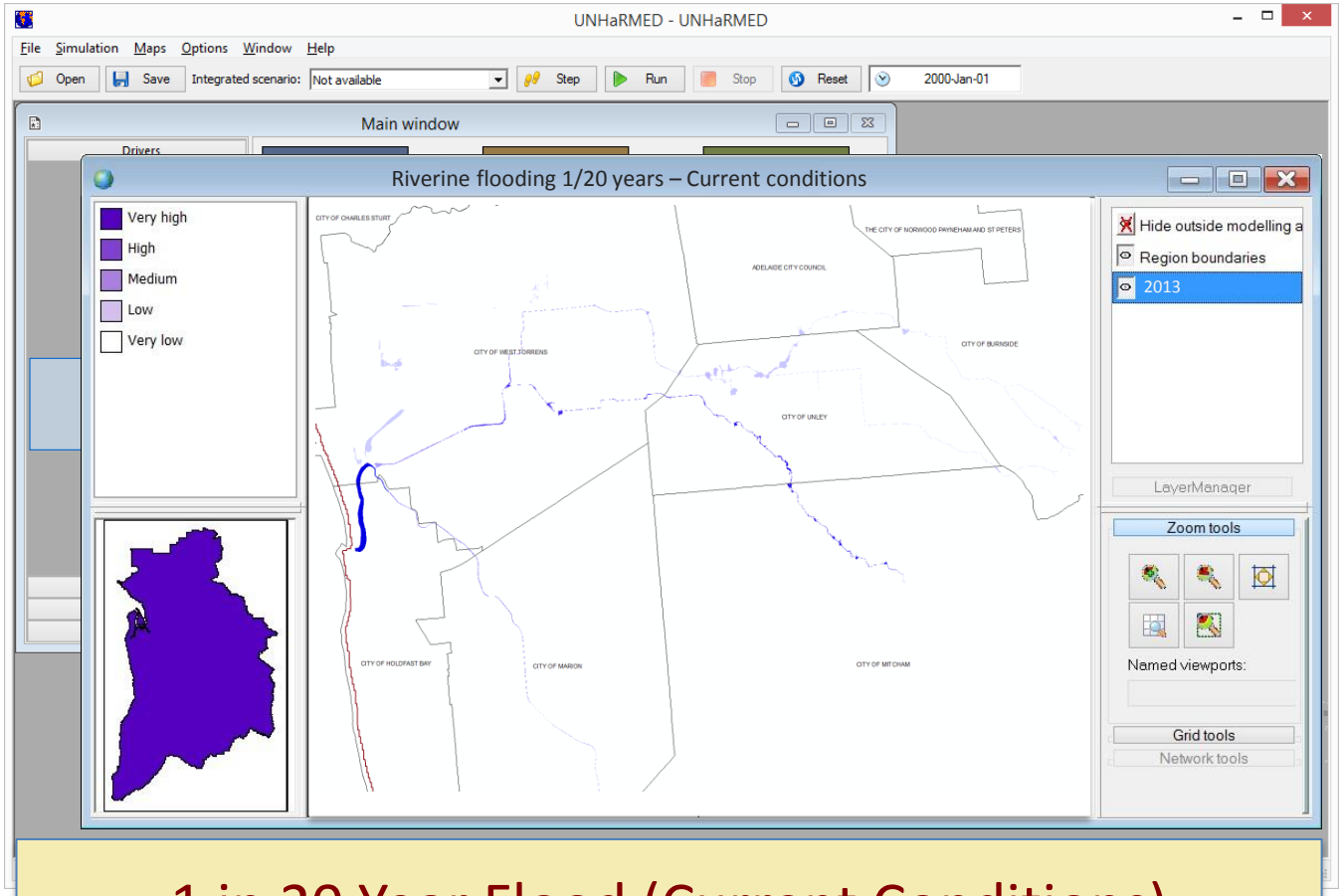
SYSTEM DIAGRAM



RIVERINE FLOODING

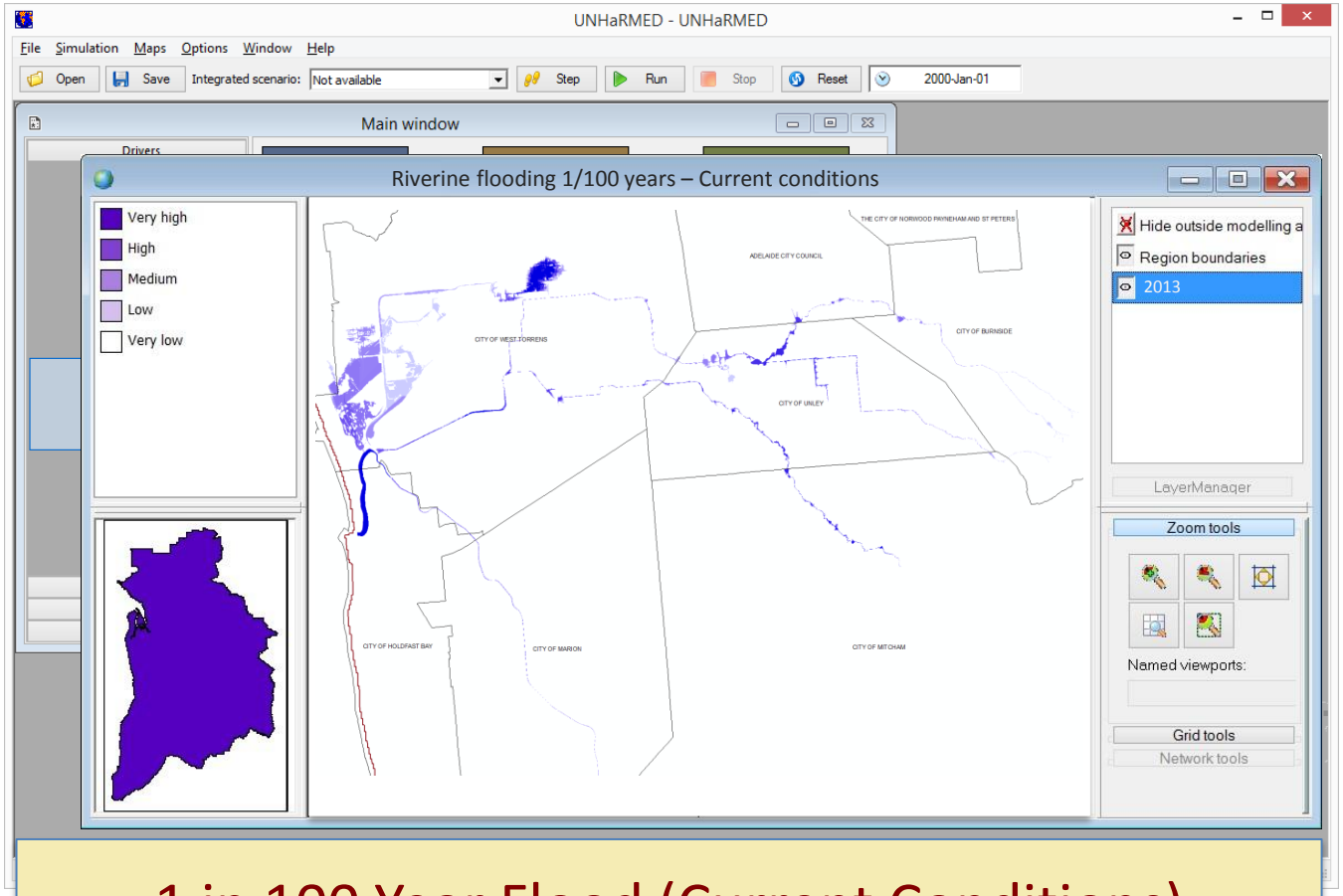


RIVERINE FLOODING



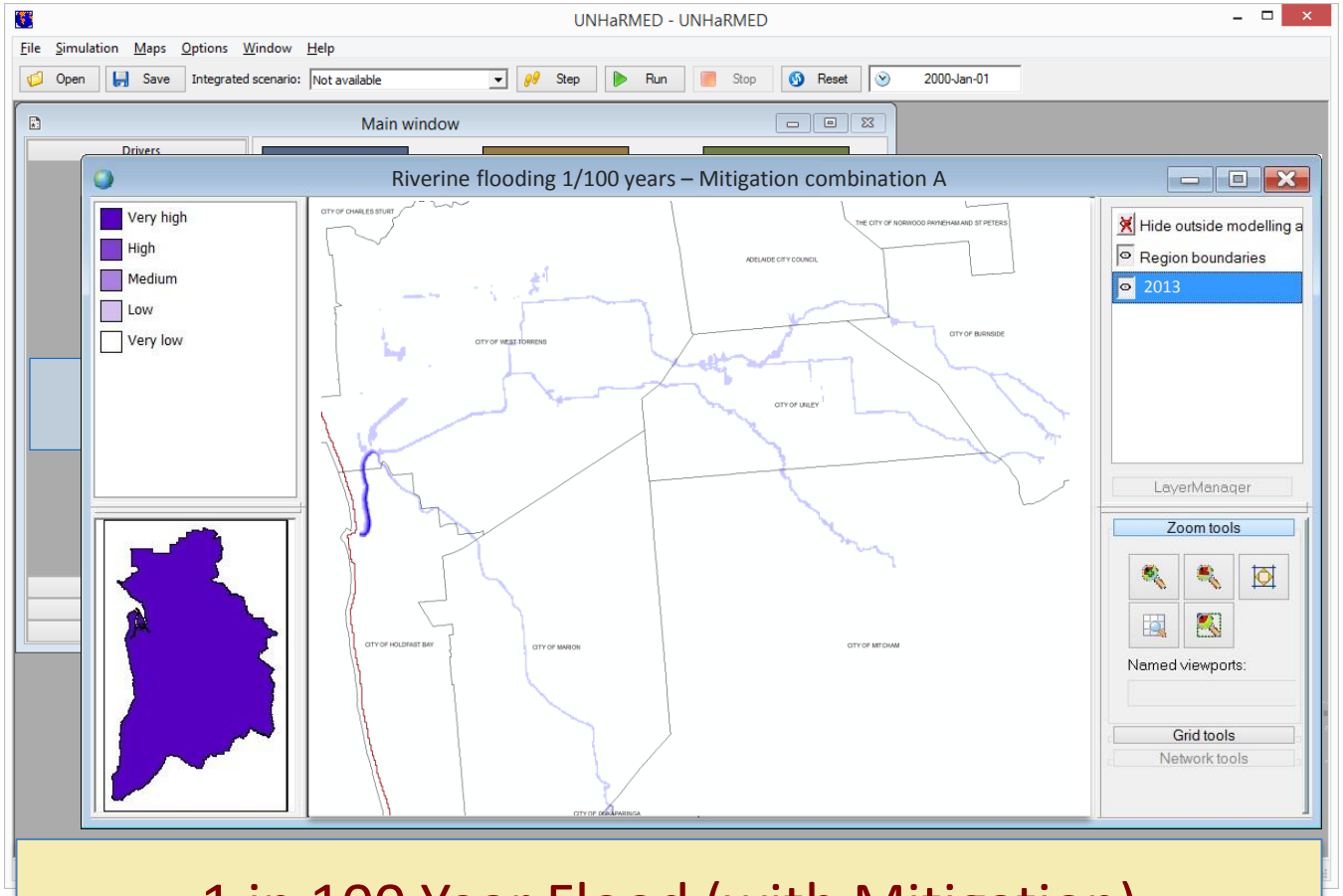
1 in 20 Year Flood (Current Conditions)

RIVERINE FLOODING



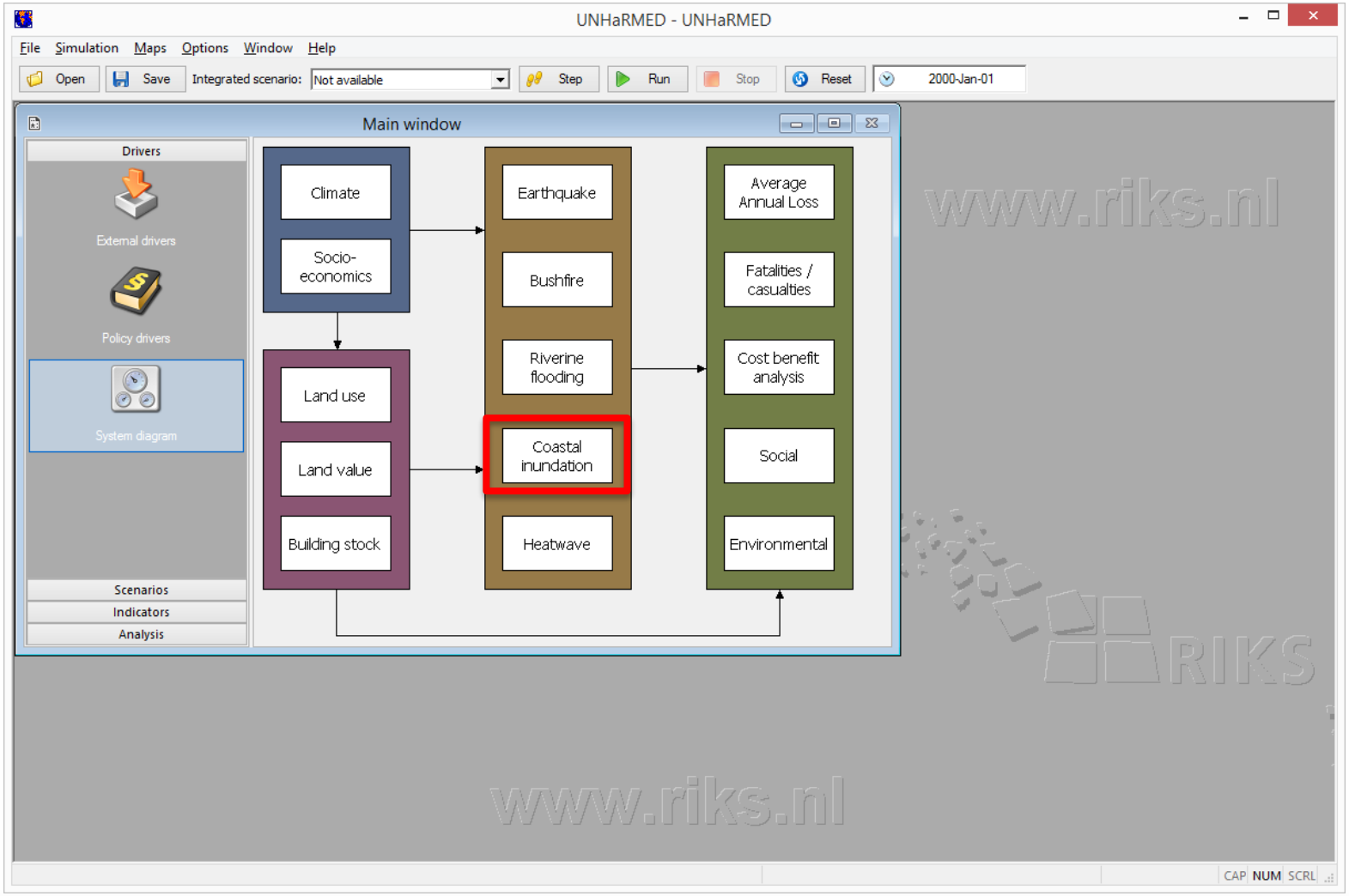
1 in 100 Year Flood (Current Conditions)

RIVERINE FLOODING

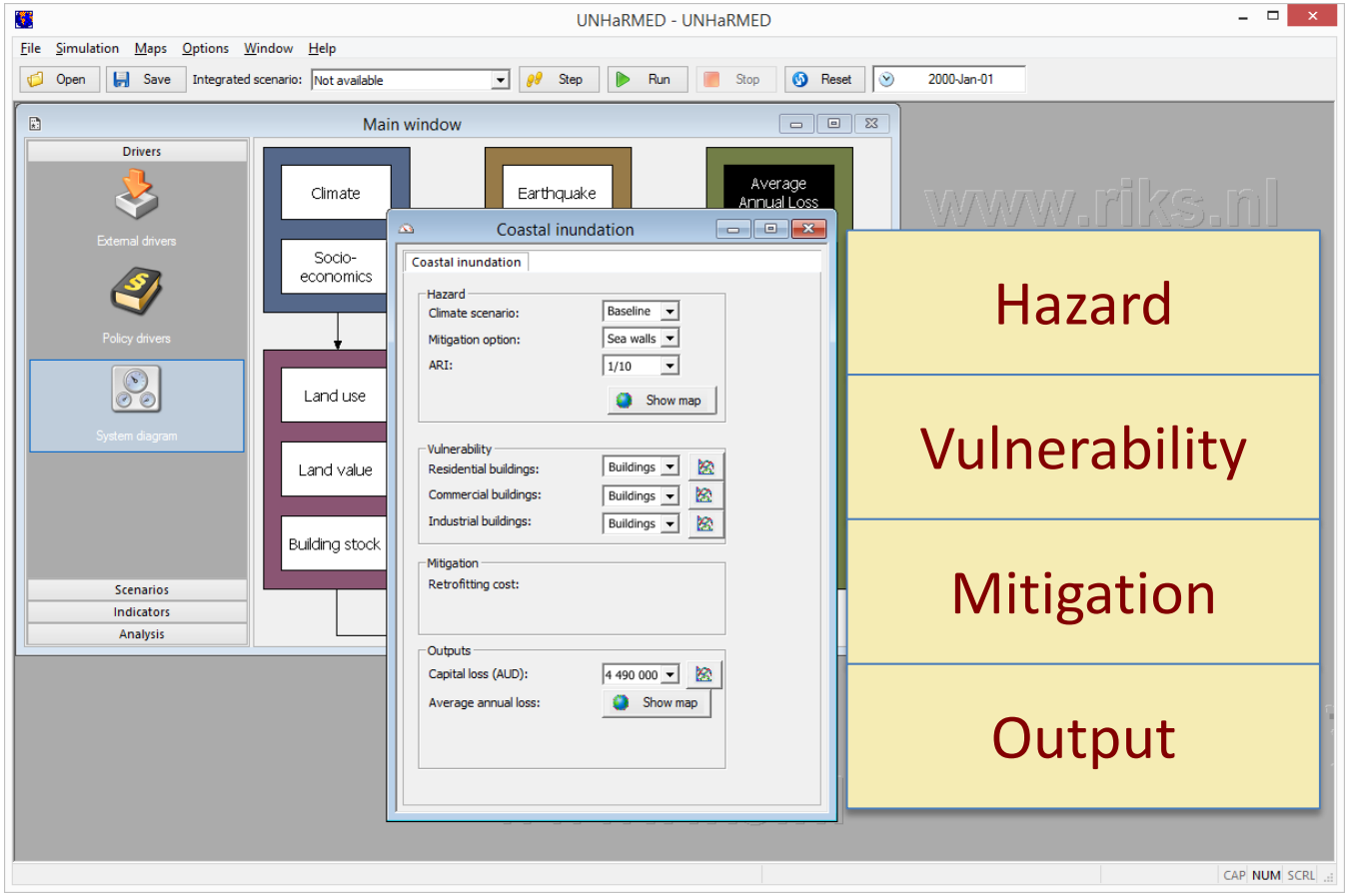


1 in 100 Year Flood (with Mitigation)

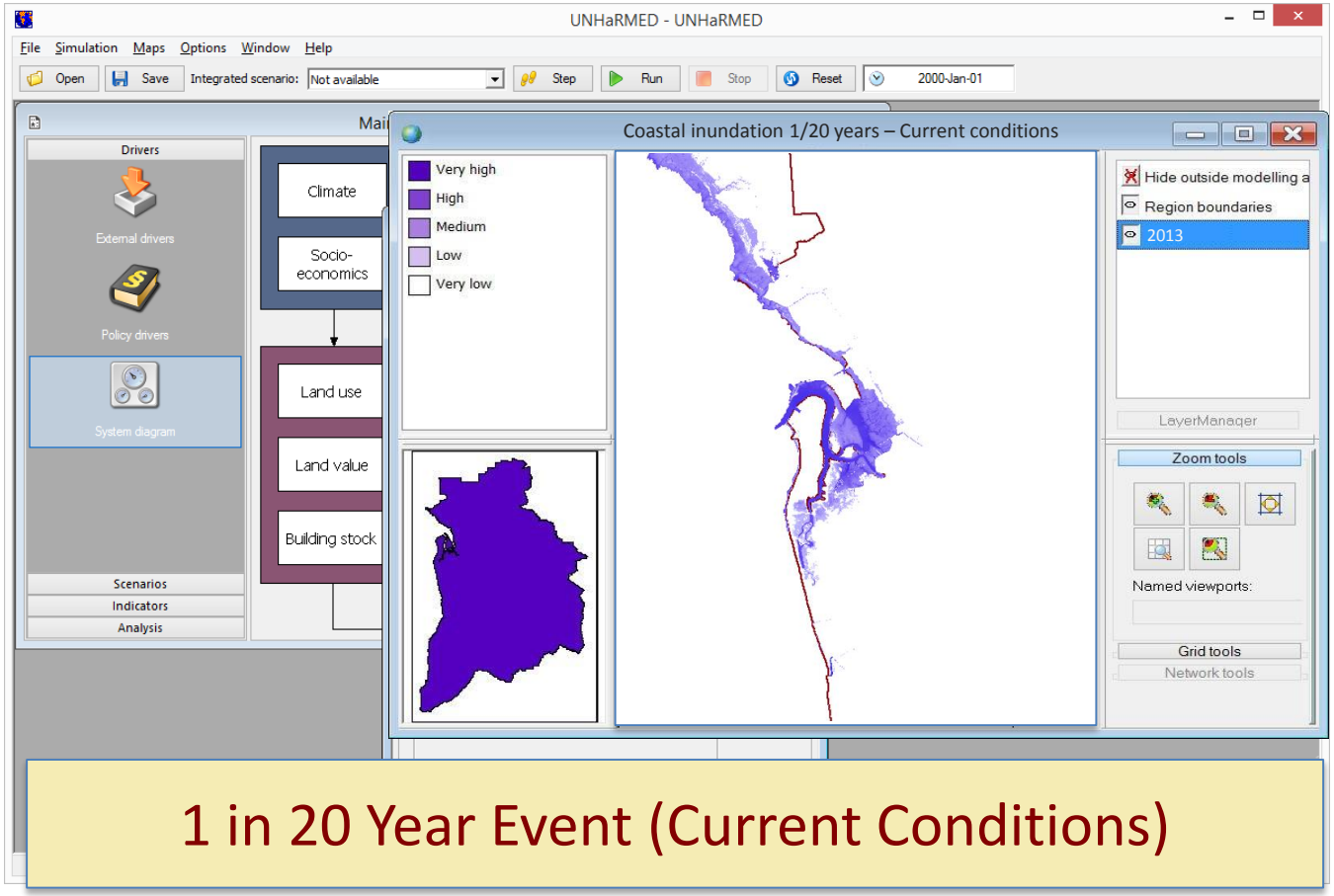
SYSTEM DIAGRAM



COASTAL INUNDATION

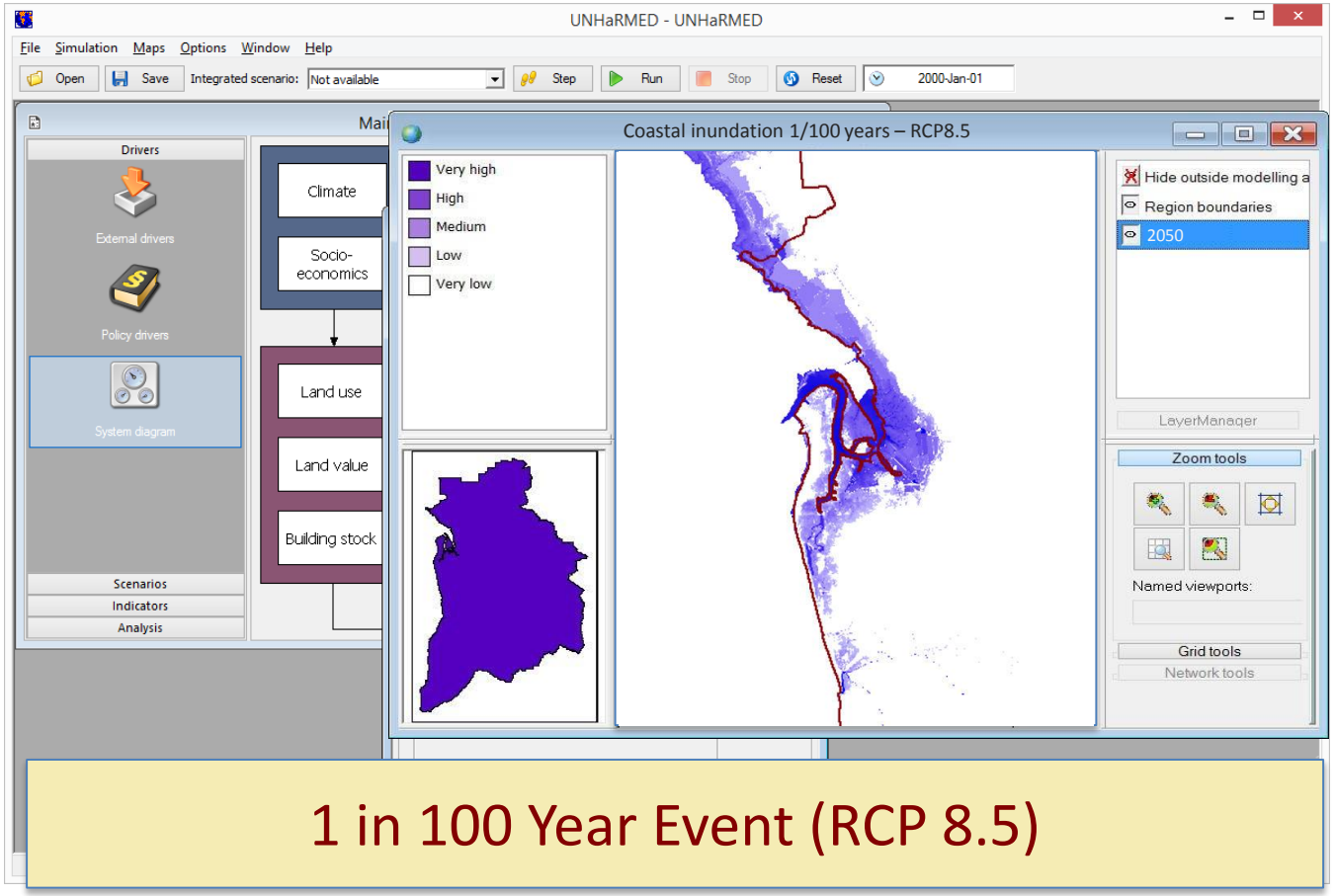


COASTAL INUNDATION



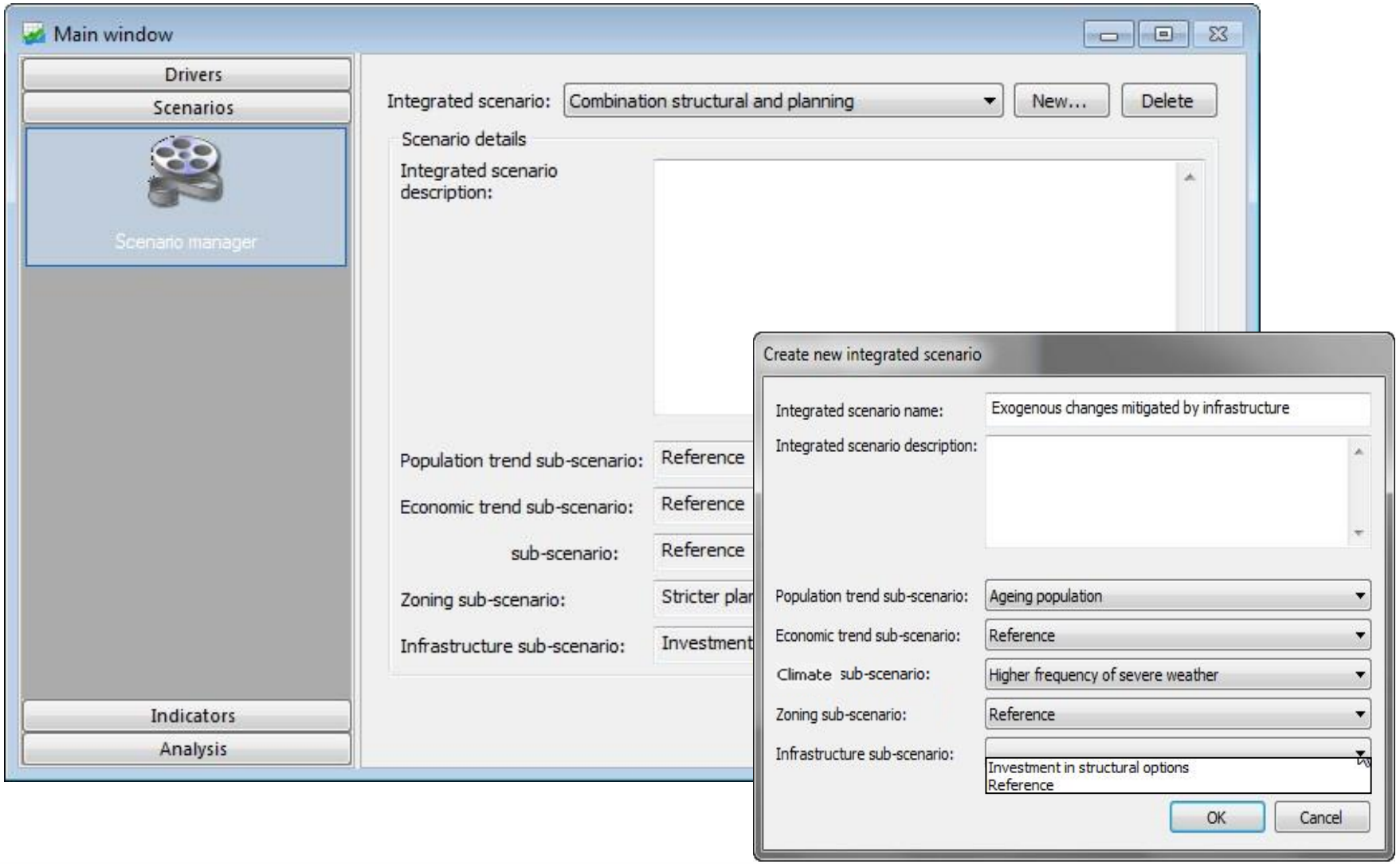
1 in 20 Year Event (Current Conditions)

COASTAL INUNDATION



1 in 100 Year Event (RCP 8.5)

SCENARIO ANALYSIS



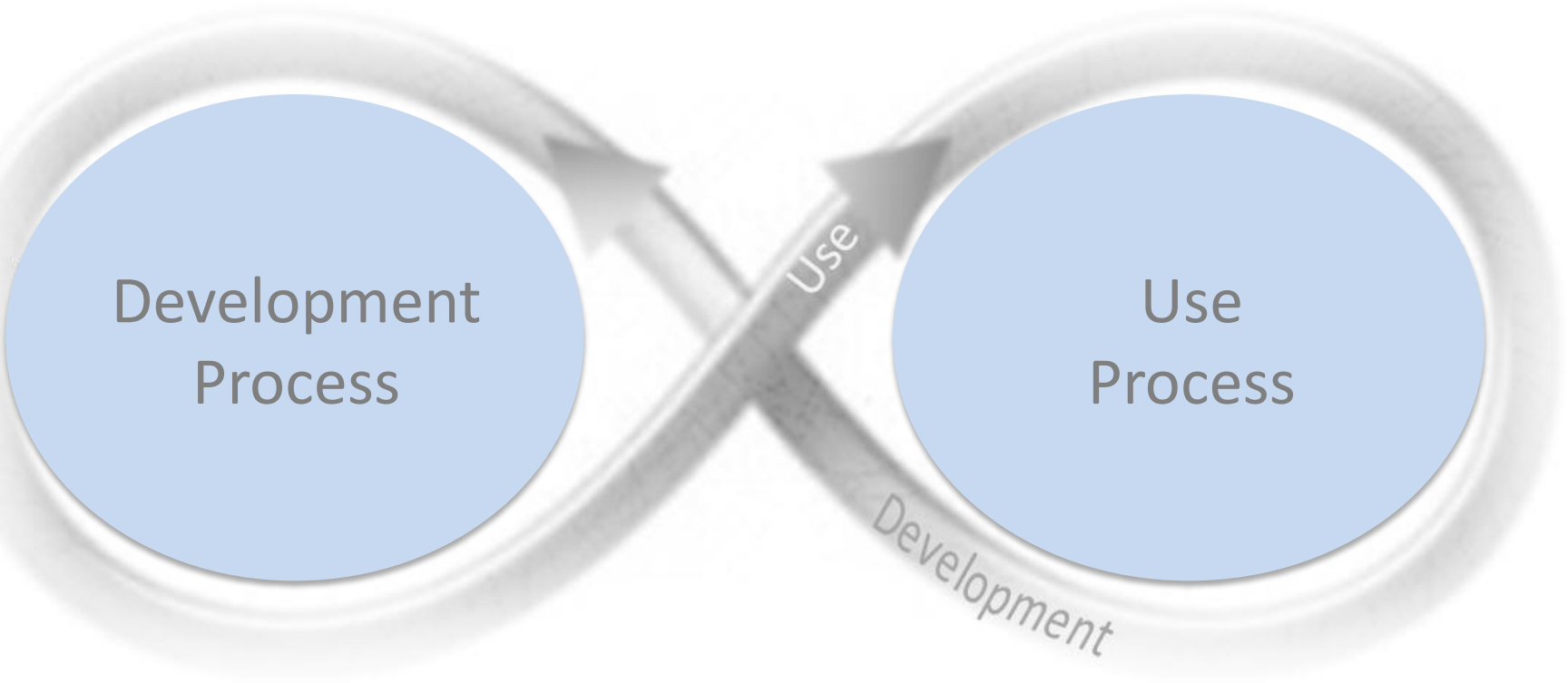
GENERIC FRAMEWORK

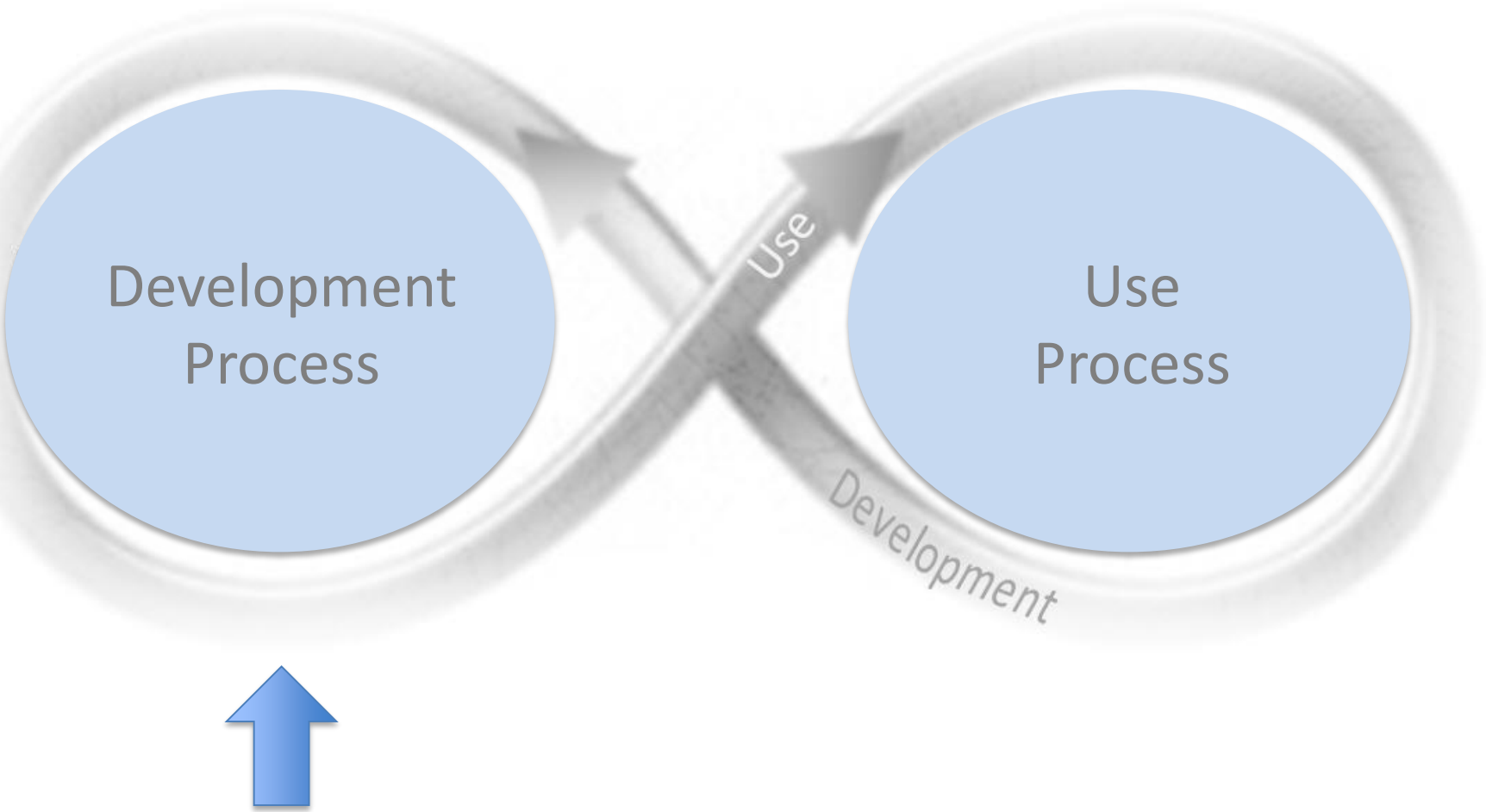
Conceptual Approach

Modelling Approach

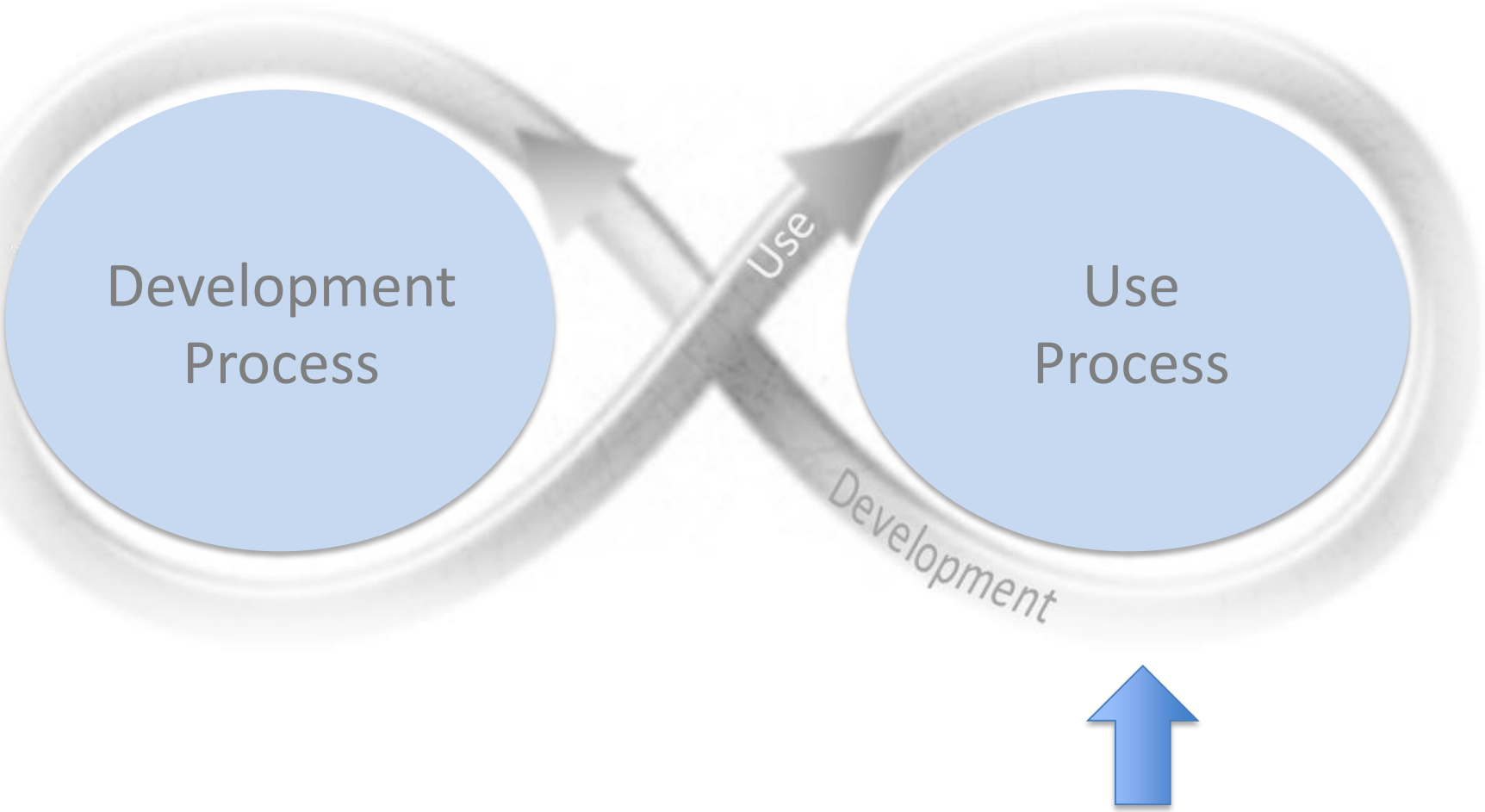
Software Framework

Case Study Development and Use


Development Process
Use
Development
Use Process


Development Process
Use
Use Process
Development

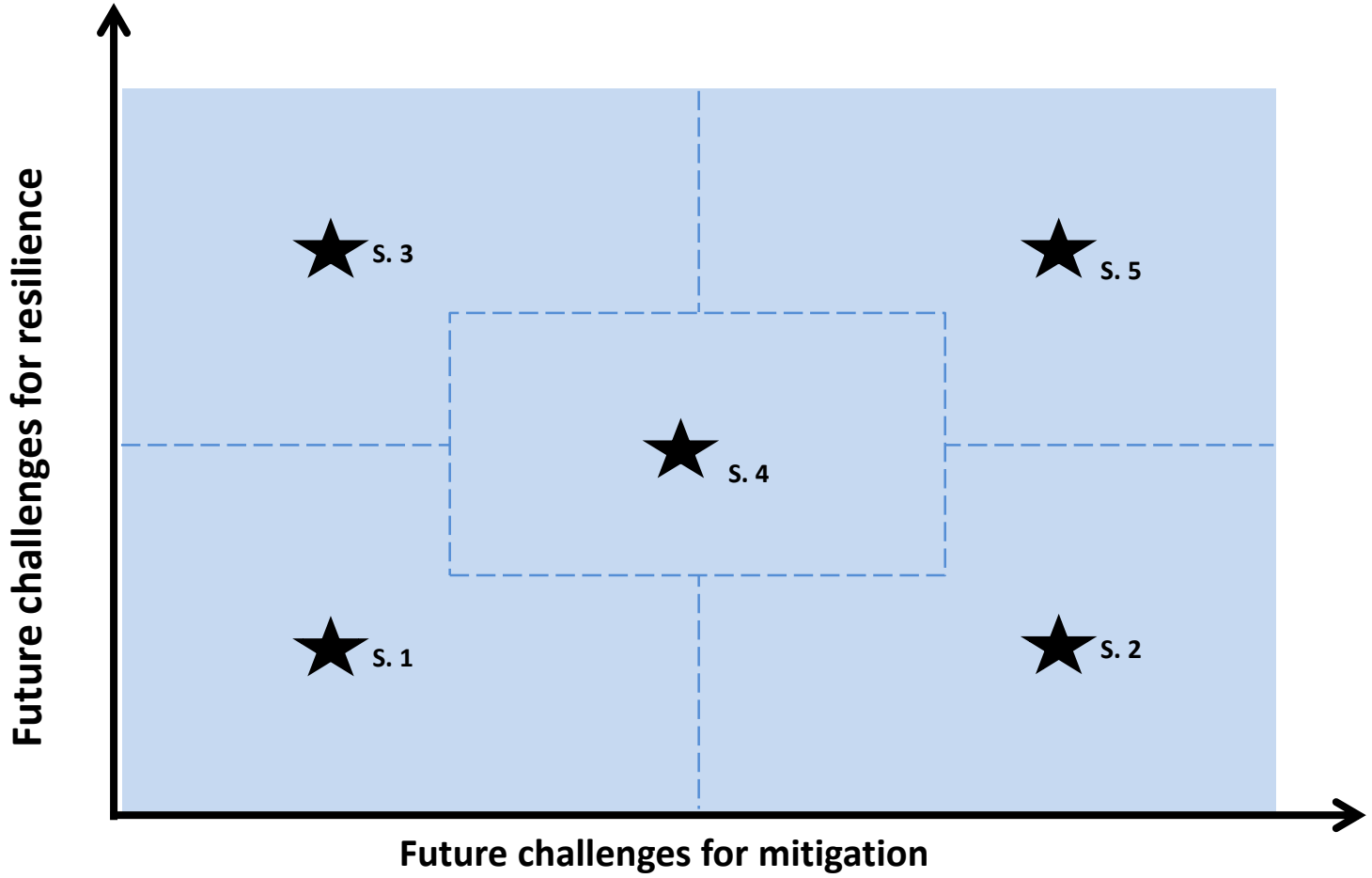
1) Questionnaires
2) Semi-structured interviews
3) Workshop 1 (requirements, policy setting, use)
4) System development (data, models integration, GUI)
5) Workshop 2 (feedback)
6) System modification)


Development Process
Use
Use Process
Development

SCENARIO INPUTS

1) Questionnaires
2) Semi-structured interviews
3) Workshop 2 (scenario construction)

APPROACH TO SCENARIO DEVELOPMENT



SCENARIO OUTPUTS

1) Modelling of scenarios
2) Workshop 3 (scenario validity and outputs)

BENEFITS OF PROPOSED APPROACH

End users involved in:

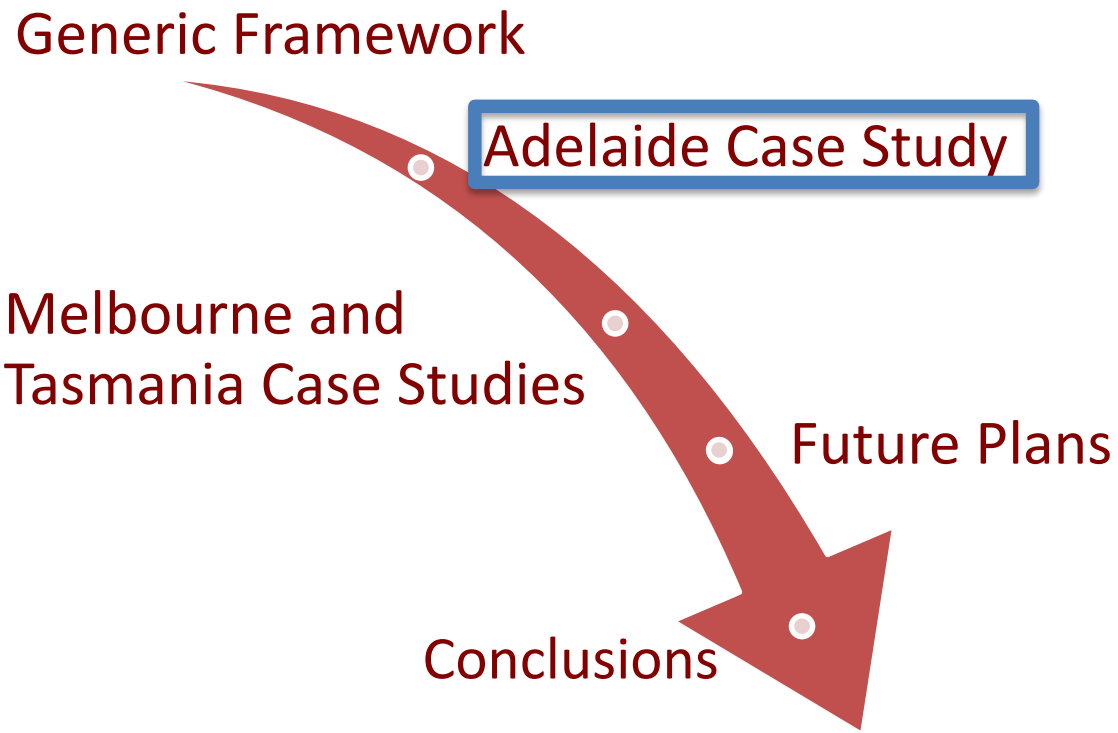
- Model development & selection
- User interface design
- Scenario development
- Policy assessment & planning

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

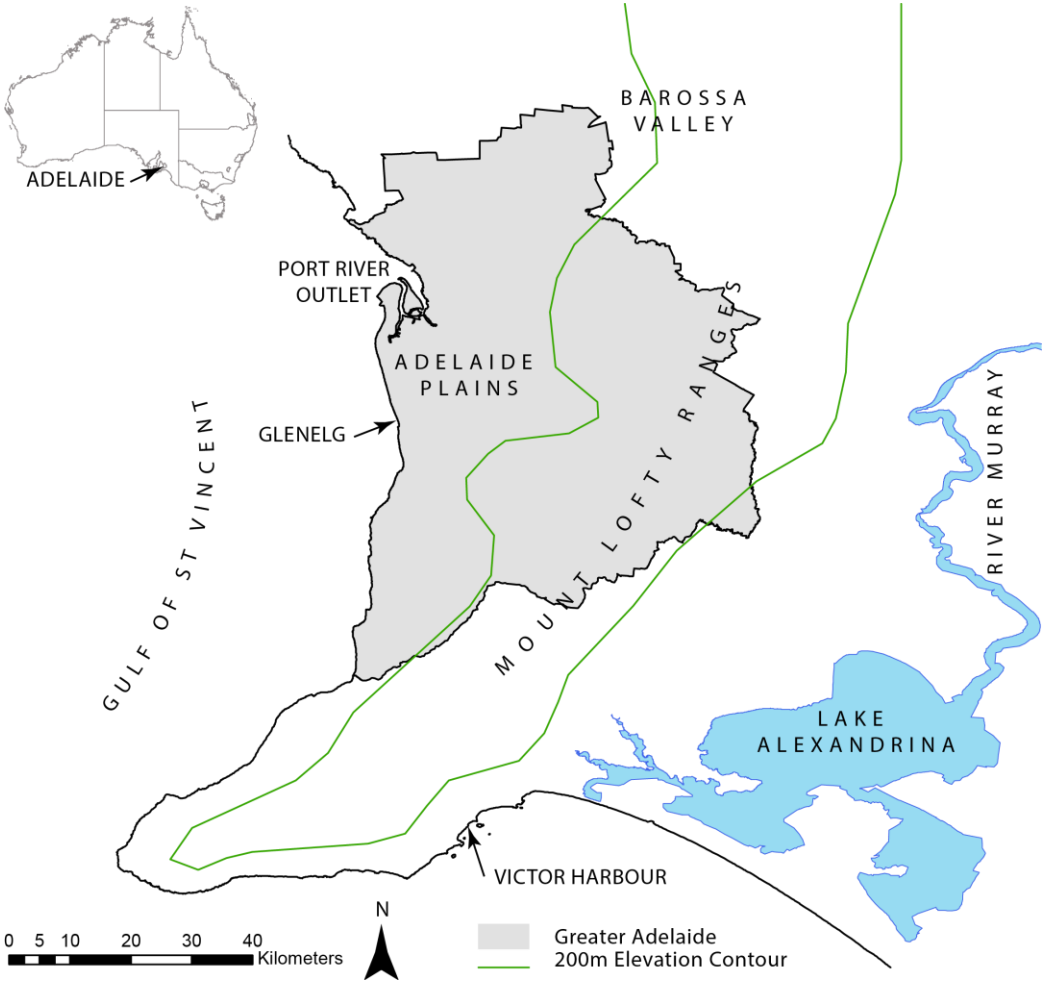
Builds strategic capacity by exploring future risk profiles

Looks towards integration of system within organisations

A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation

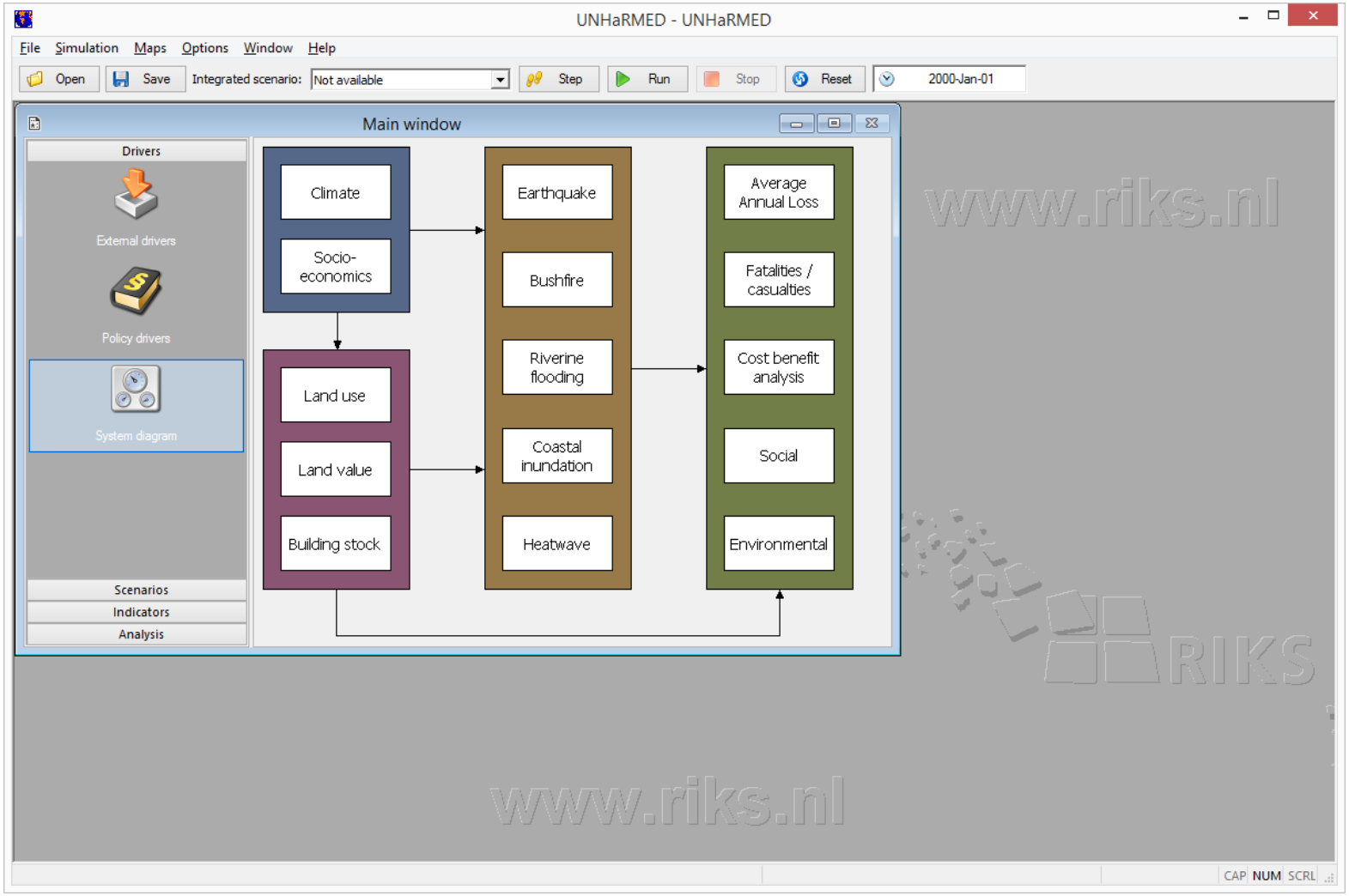


GREATER ADELAIDE CASE STUDY



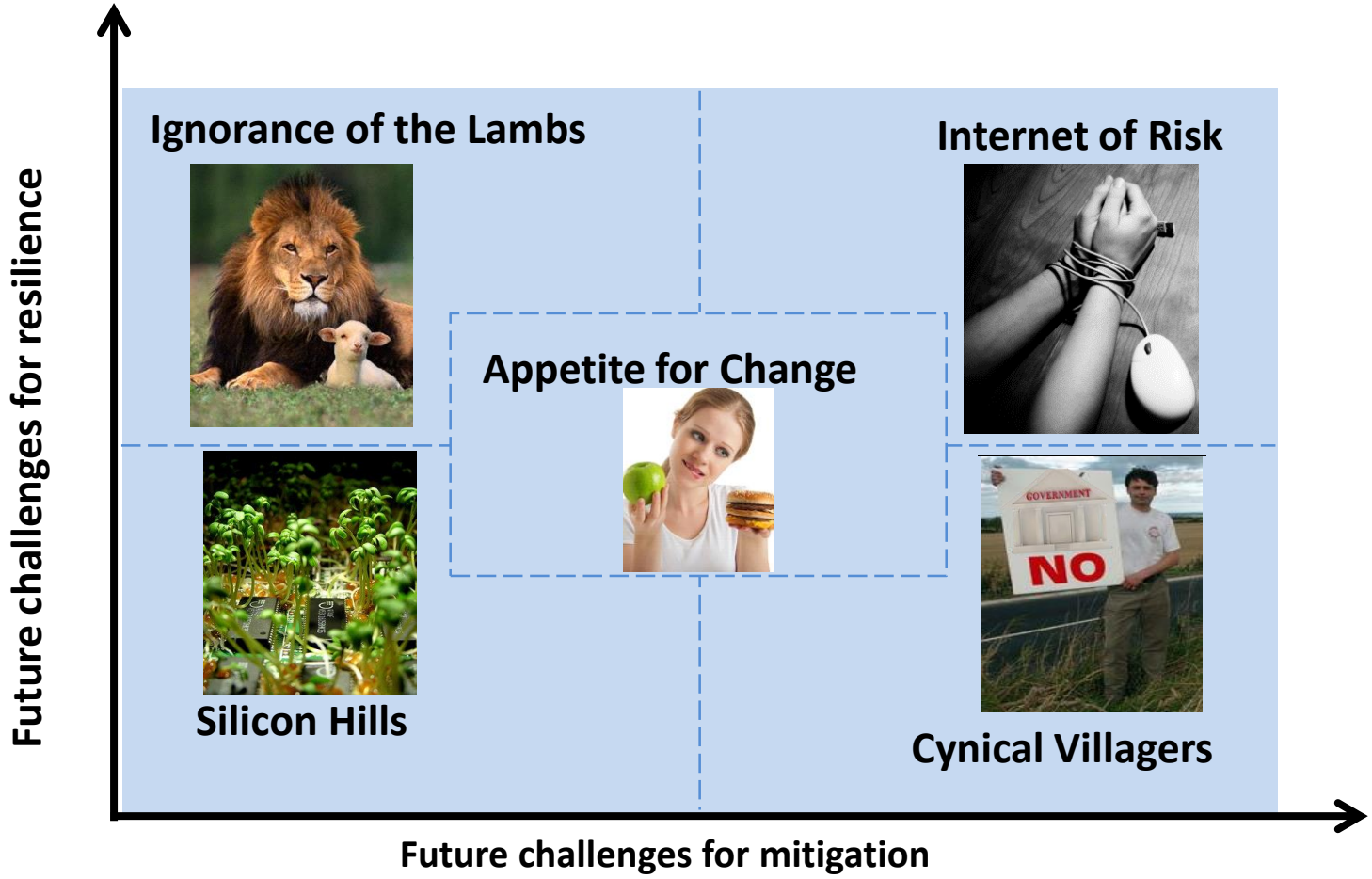
ADAPTIVE
GOVERNANCE
STRUCTURAL

SYSTEM DIAGRAM

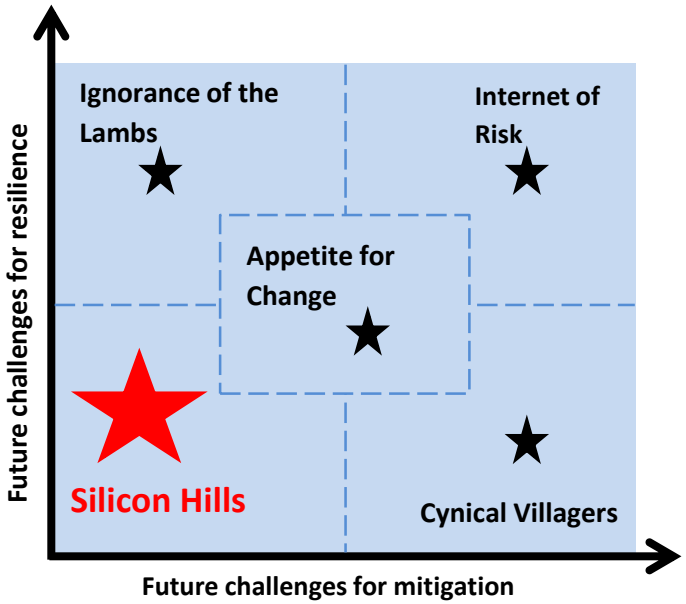


HOLISTIC POLICY DEVELOPMENT
CBA – RIGOROUS &
data more open
com better
2015
2020
2030
2040
multijurisdictional policy blocked by ind. jurisdiction agendas
balancing of priorities
disaster

SCENARIOS FOR GREATER ADELAIDE



Scenario 1: Silicon Hills



Technology driven economy

Fuelled by skilled locals and immigrants

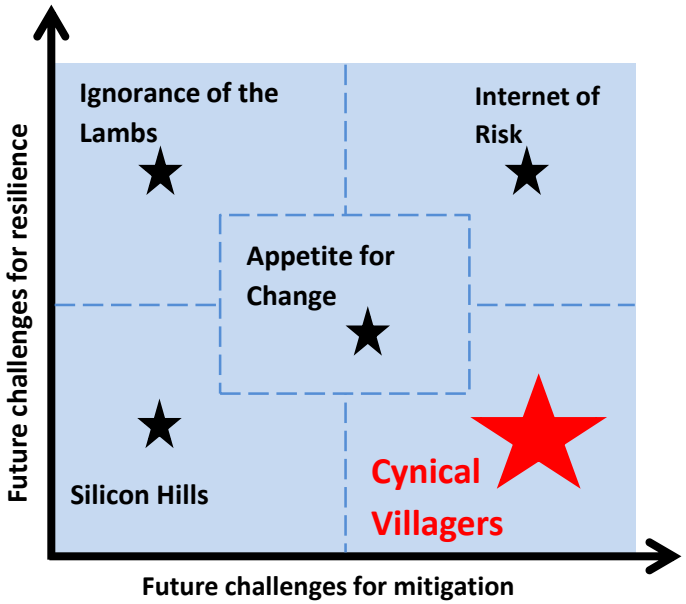
Enjoying the nature and lifestyle of Adelaide

High multi-culturalism, and appreciation of risks

Work flexibility, encouraging community spirit

Emphasis on urban design and building resilience

Scenario 2: Cynical Villagers



Ageing population, slowing population growth

Growth in rural residential living, mixed with agriculture and nature

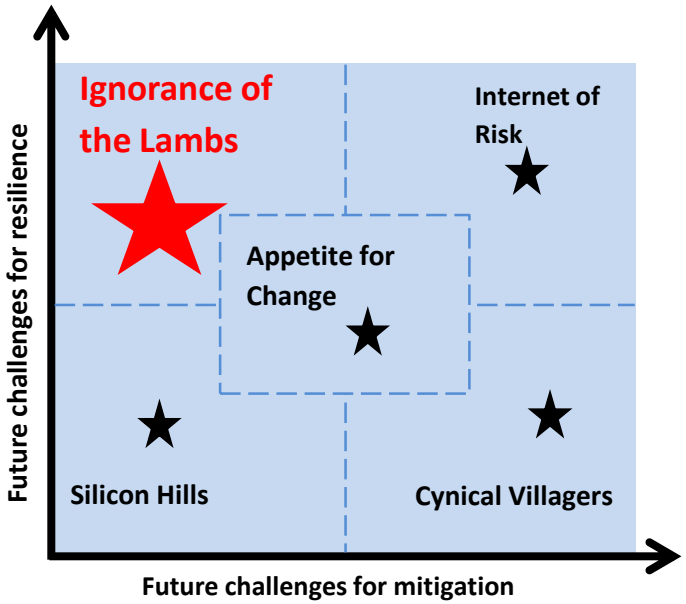
Shift from manufacturing to small scale agriculture

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



Large population growth, high immigration

Increasing commuter lifestyle, low cost housing

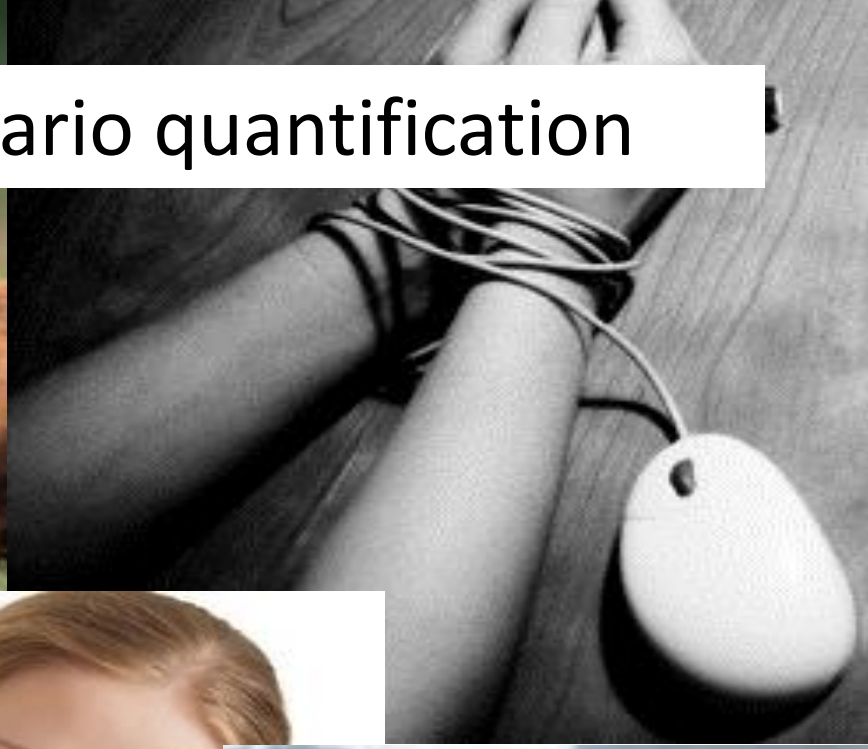
Loss of manufacturing, economic decline

Increasing community vulnerability & government reliance

Those who can leave do so

Ageing infrastructure, poorly maintained

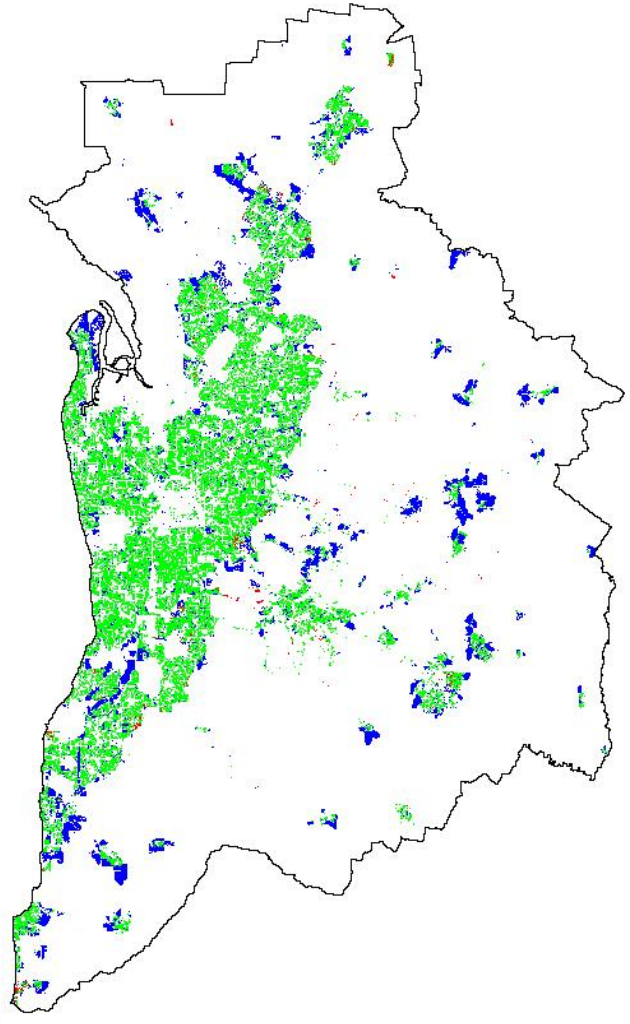
Scenario quantification

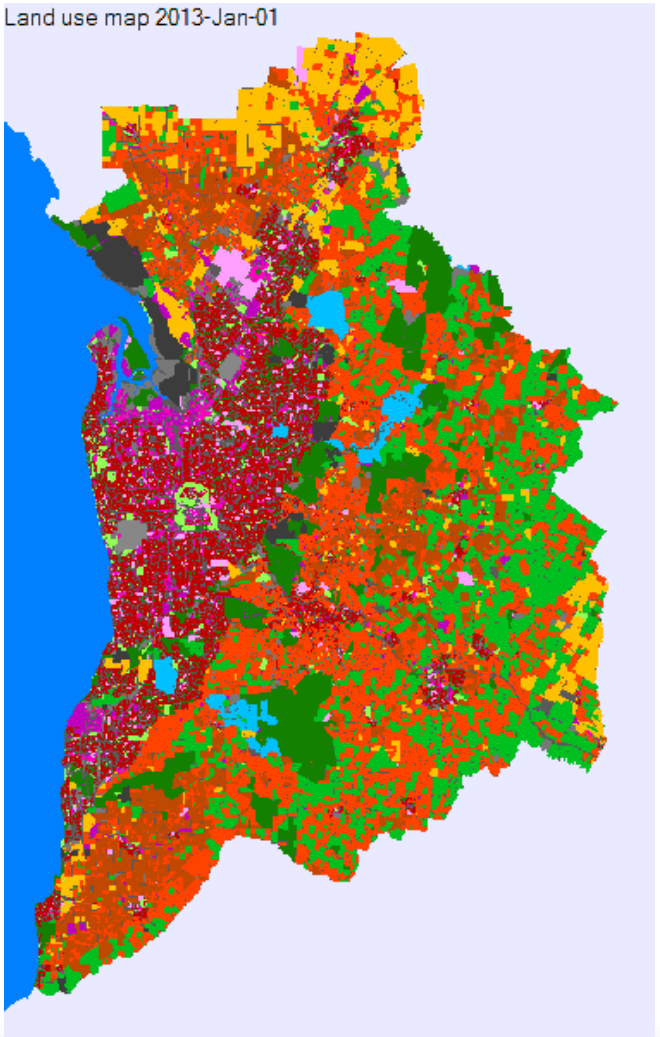


Main scenario drivers and outcomes

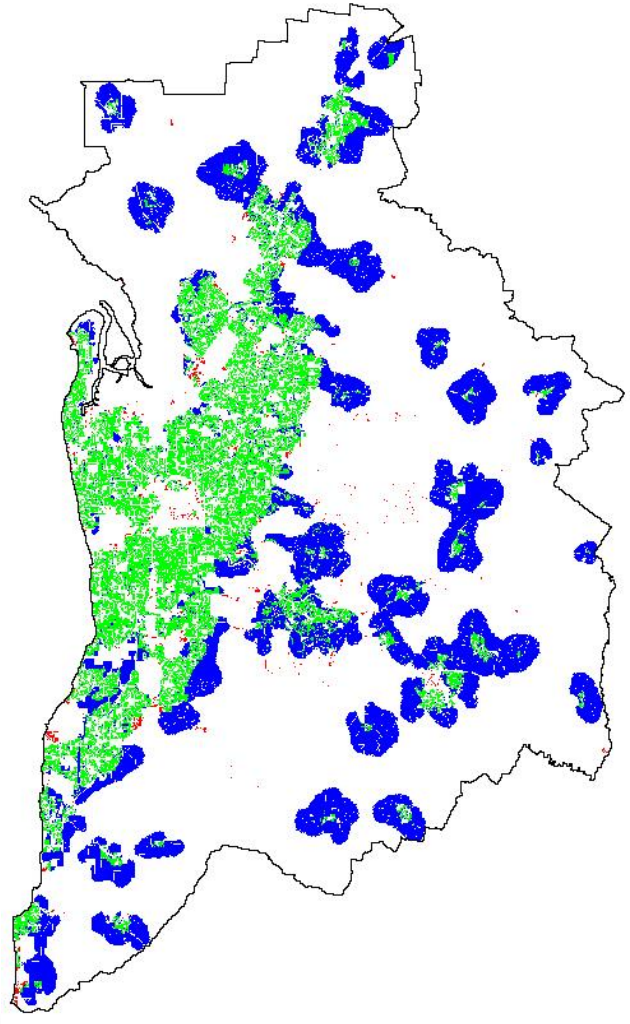
	Silicon Hills	Cynical Villagers	Ignorance of the Lambs	Appetite for Change	Internet of Risk
Population in 2050	1.9 M	1.5 M	2.5 M	1.8 M	1.5 M
Economy					
Community resilience					
Building stock resilience					
Residential land use developments	*Gradual growth urban and rural areas*	*Large increase in rural residential, mixed with other land uses*	*Residential commuter communities in the hills*	*Infill, some sprawl on the fringe and rural residential development*	*Large increase in rural residential*
Land use planning					
Education & awareness					
Structural mitigation					

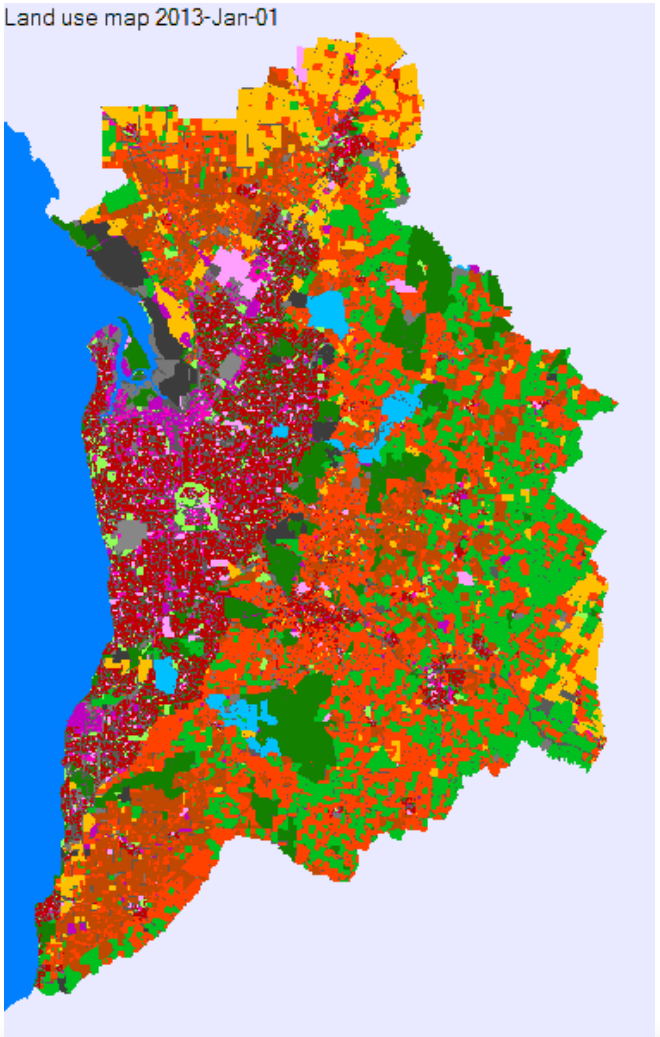
APPETITE FOR CHANGE – LANDUSE CHANGE



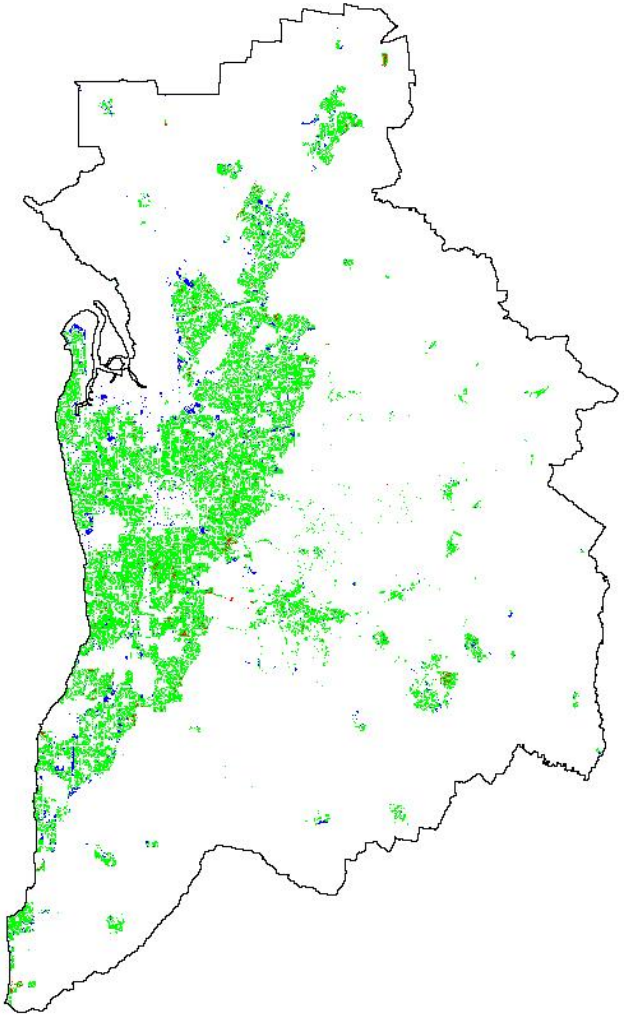


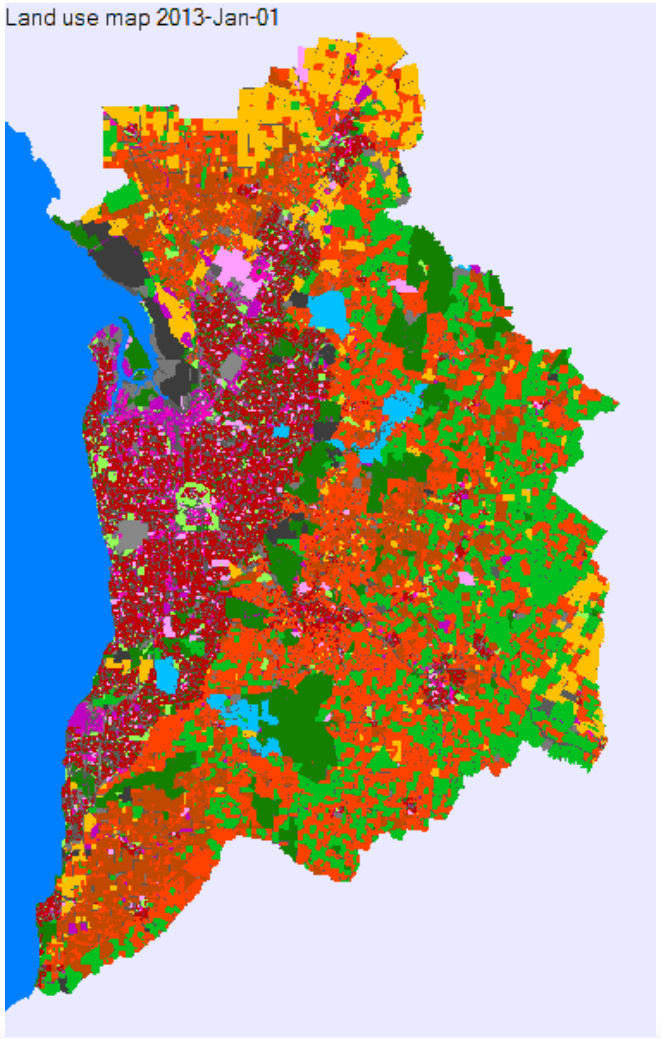
IGNORANCE OF THE LAMBS – LANDUSE CHANGE



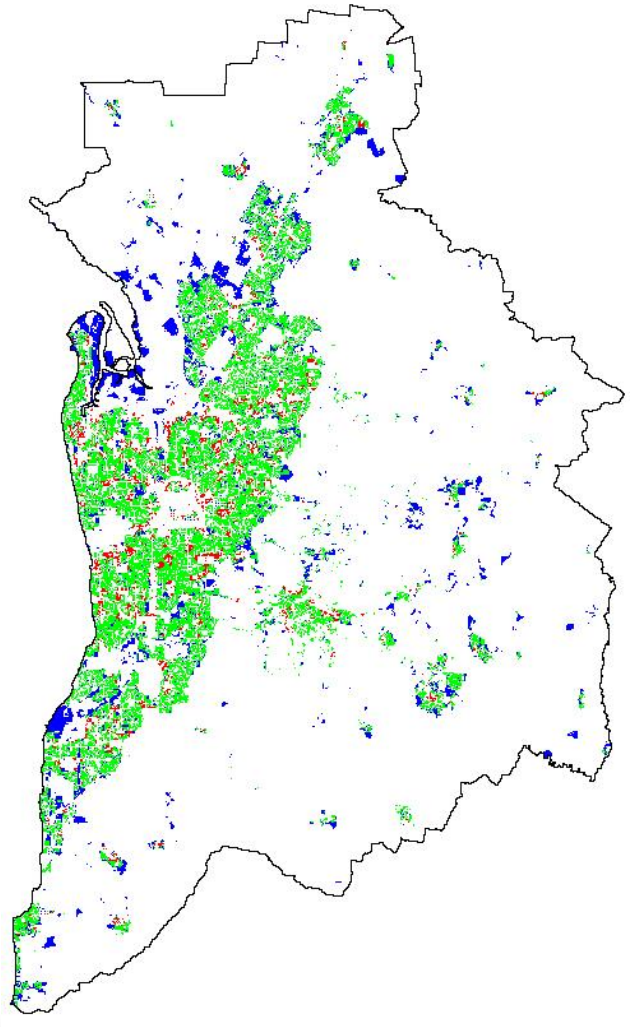


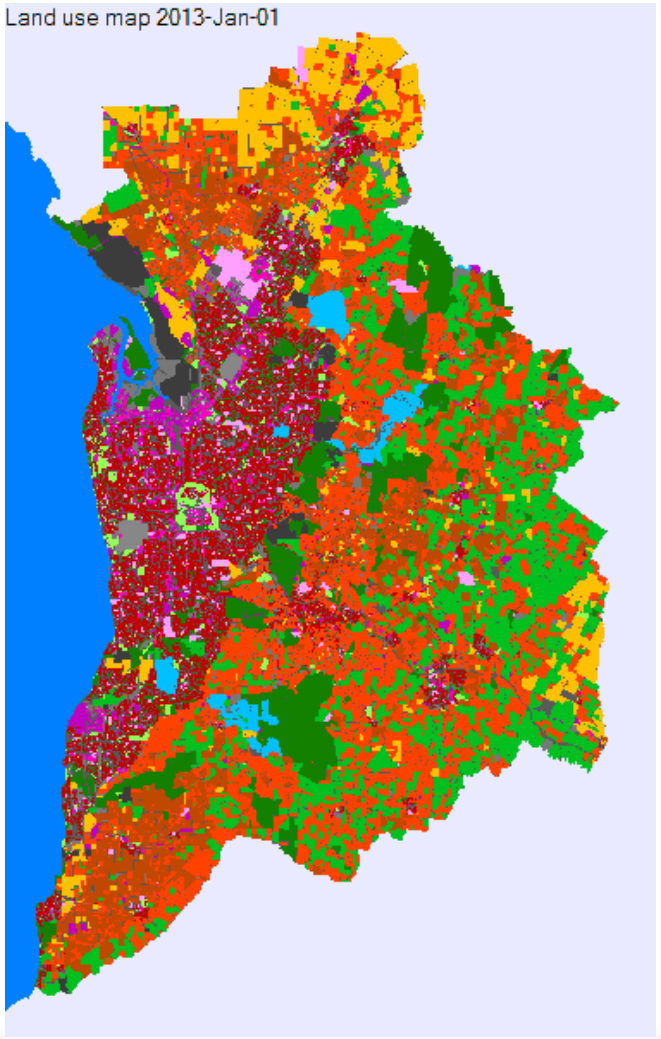
CYNICAL VILLAGERS– LANDUSE CHANGE



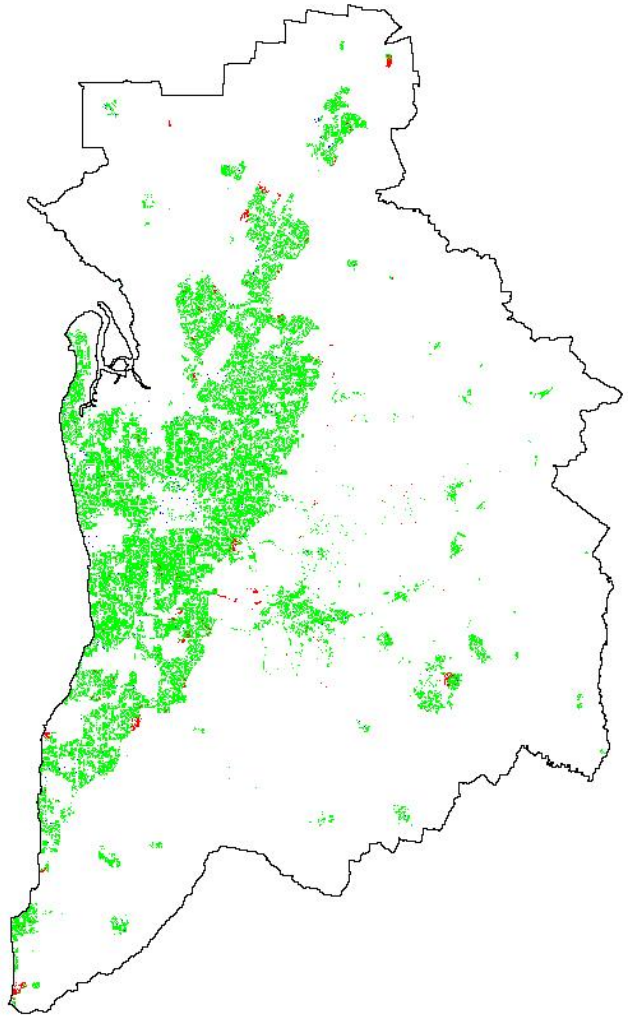


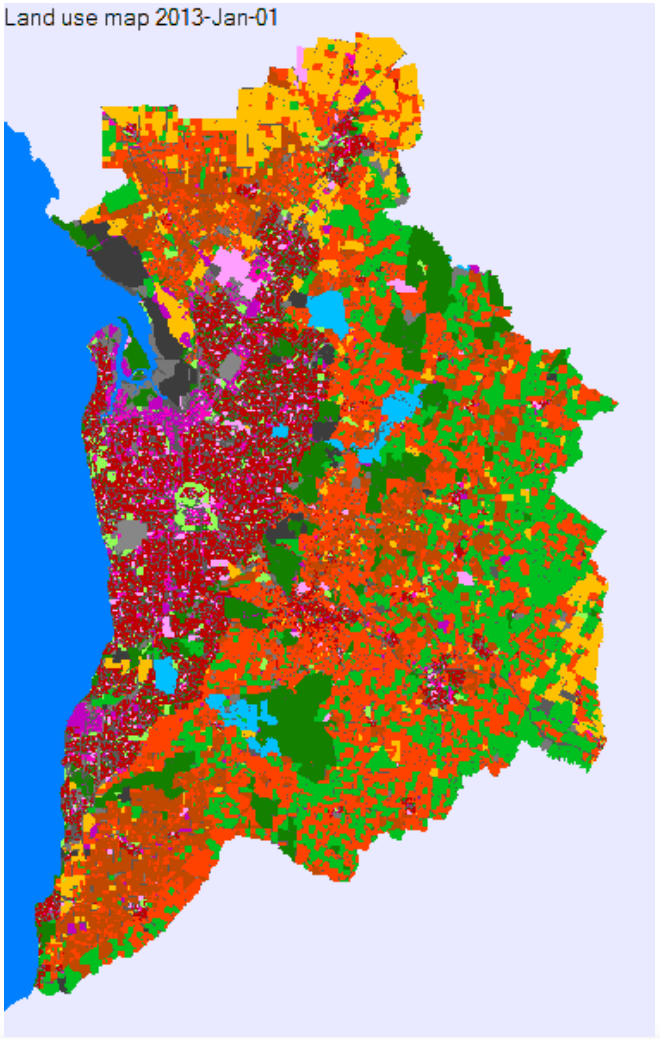
SILICON HILLS – LANDUSE CHANGE





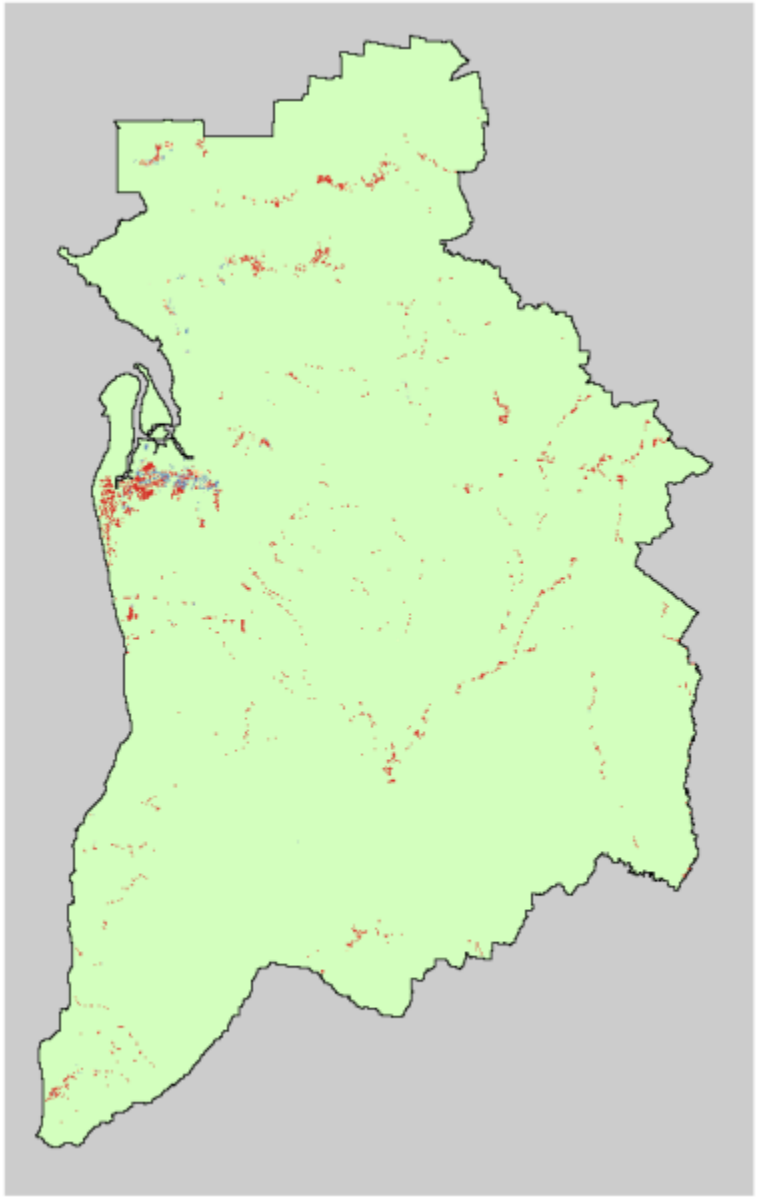
INTERNET OF RISK – LANDUSE CHANGE





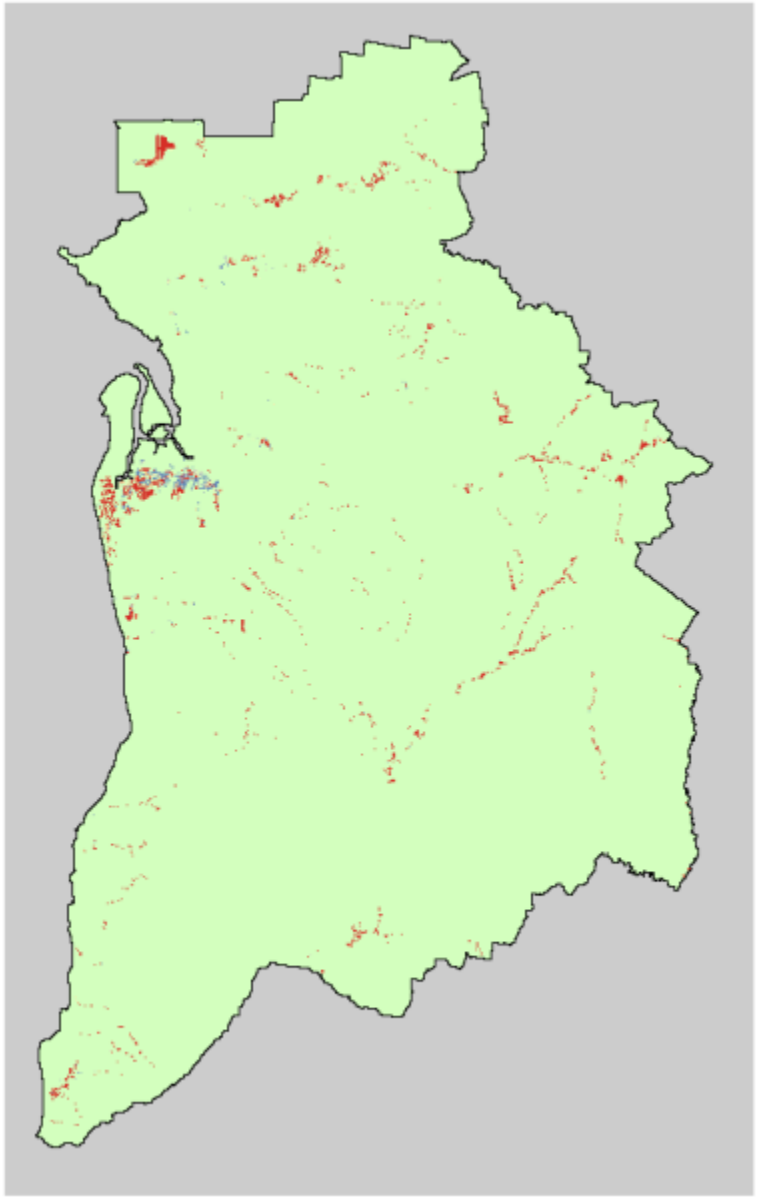
FLOOD DAMAGE (1 IN 500)

APPETITE FOR CHANGE



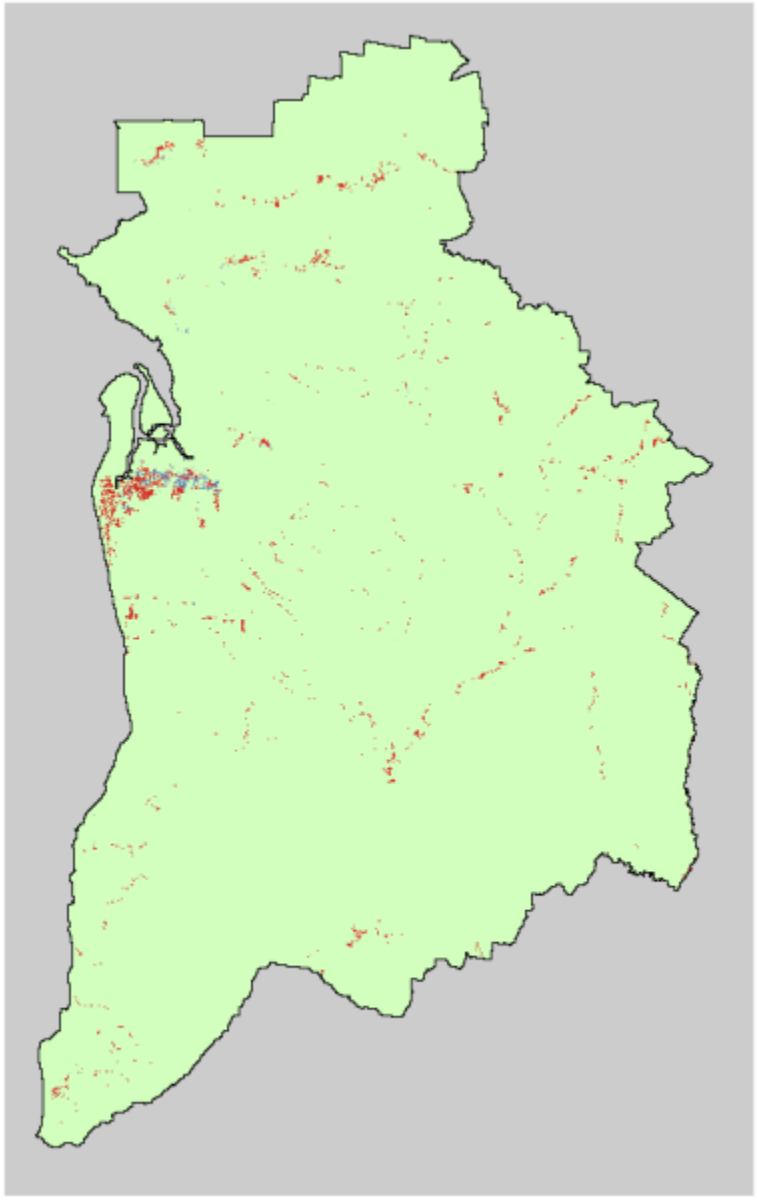
FLOOD DAMAGE (1 IN 500)

IGNORANCE OF THE LAMBS



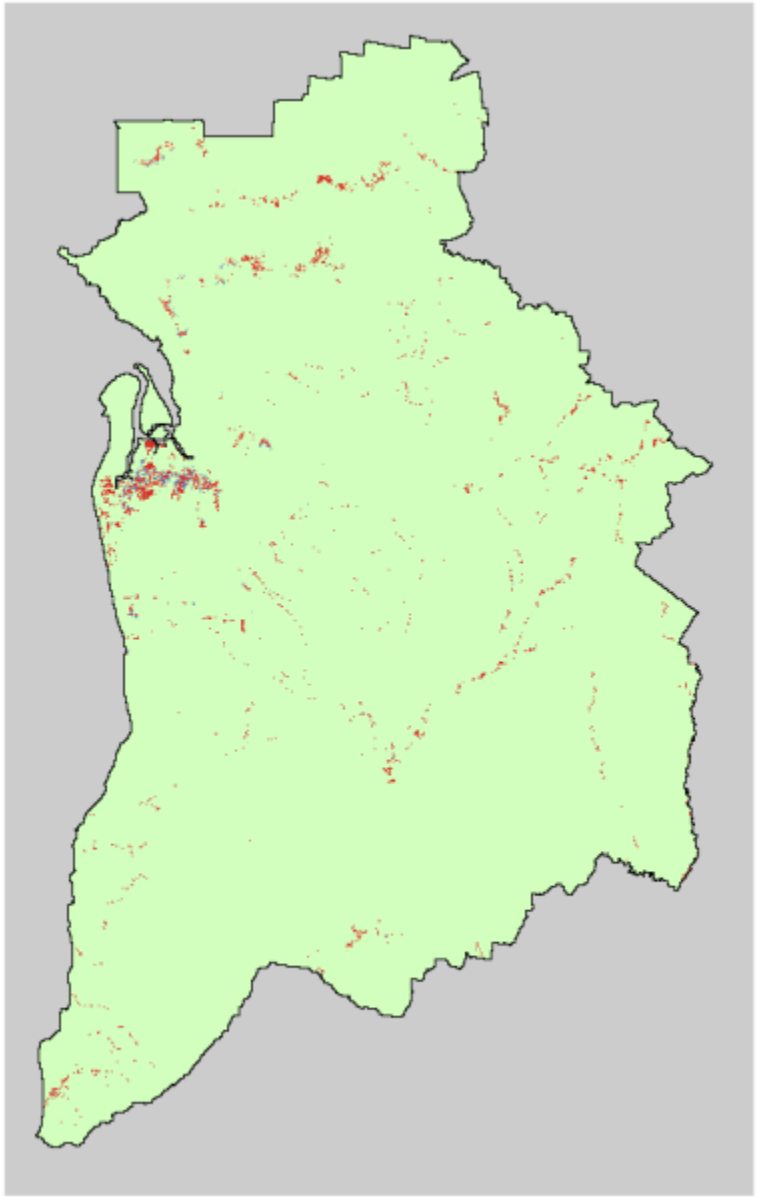
FLOOD DAMAGE (1 IN 500)

CYNICAL VILLAGERS



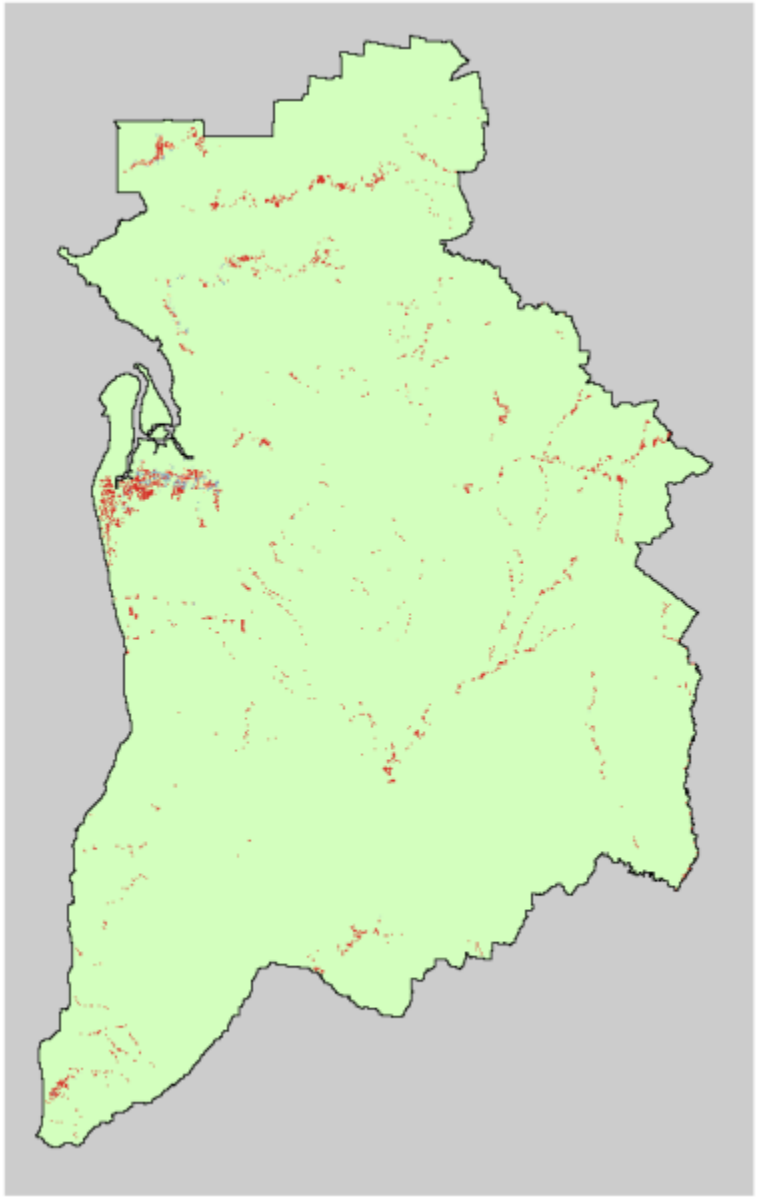
FLOOD DAMAGE (1 IN 500)

SILICON HILLS

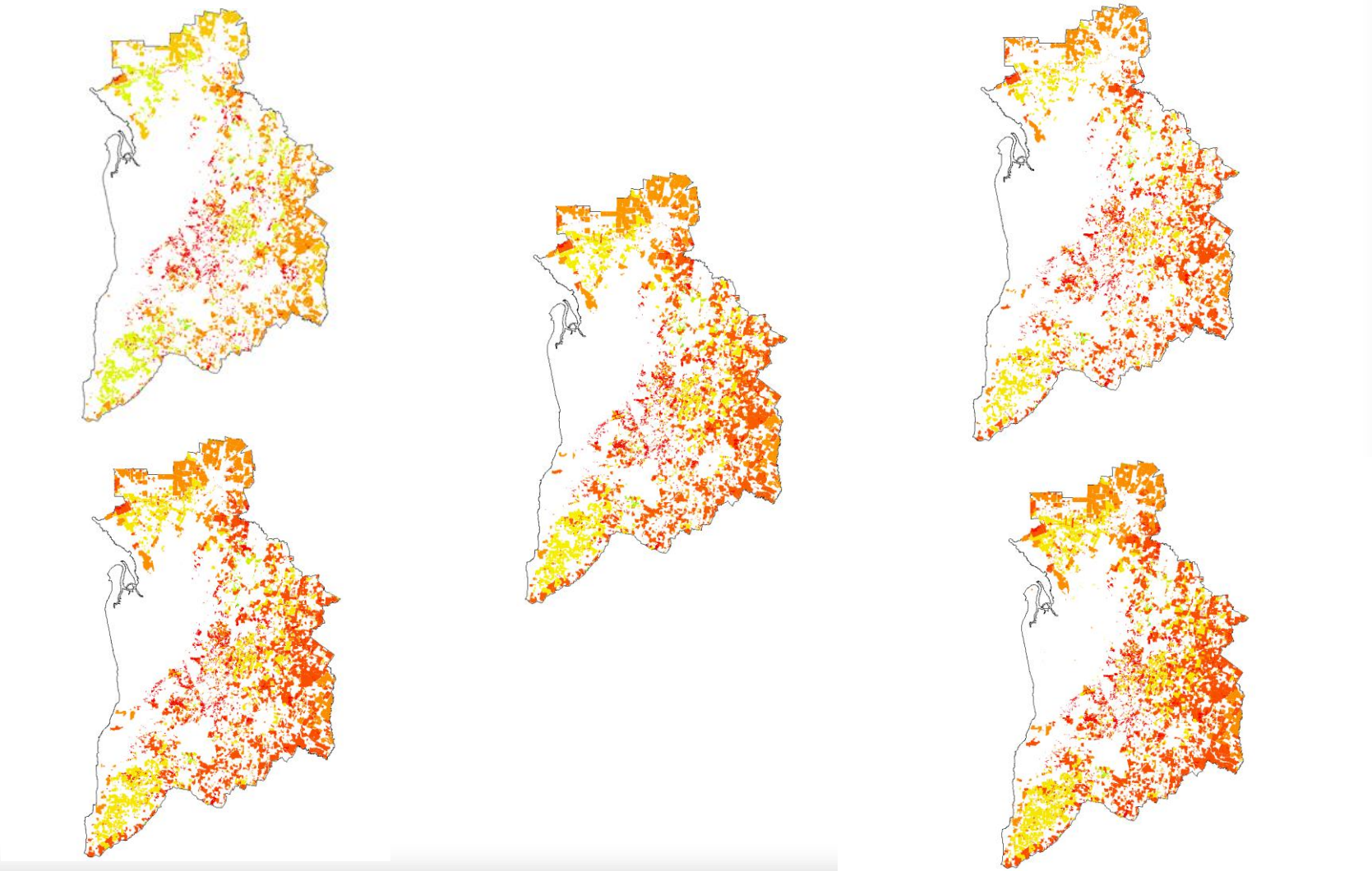


FLOOD DAMAGE (1 IN 500)

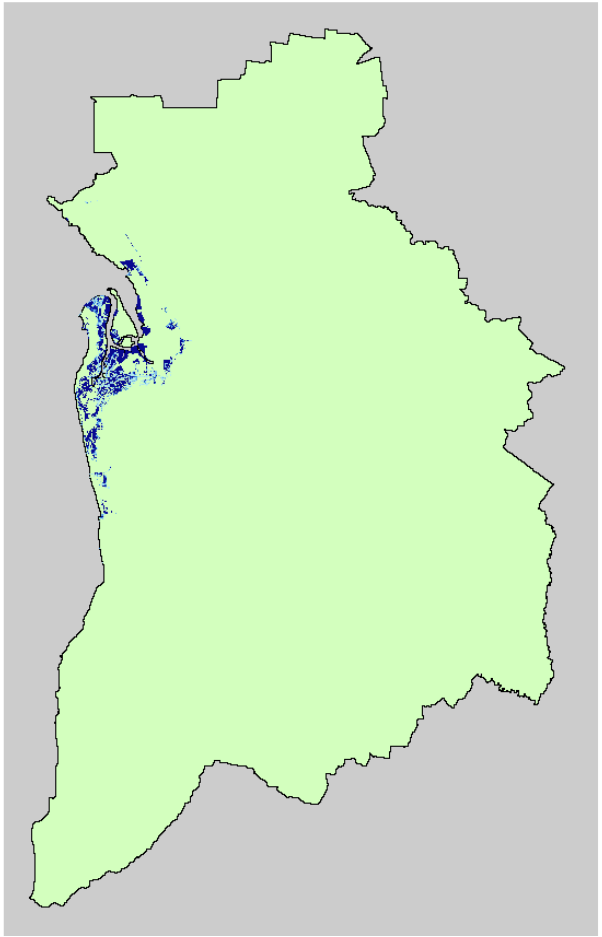
INTERNET OF RISK



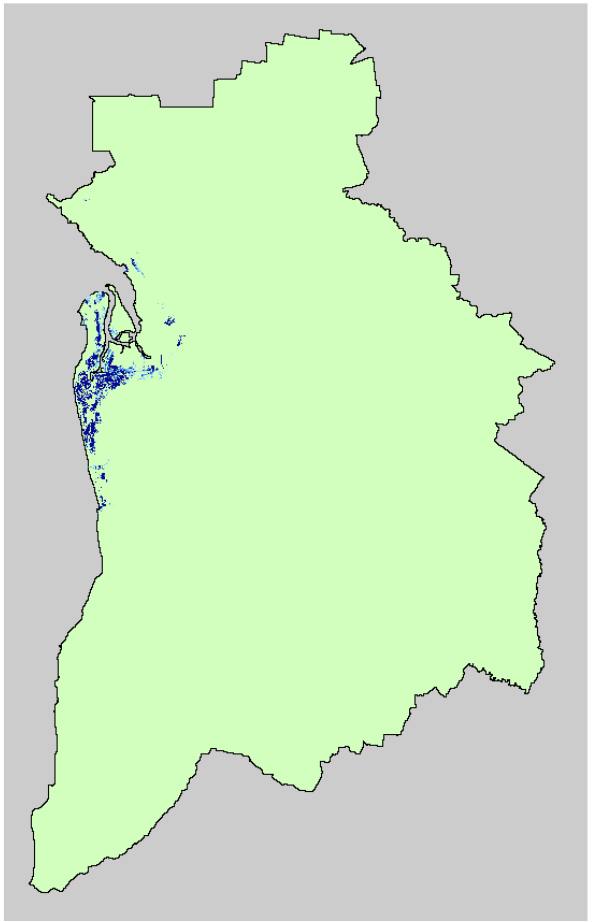
BUSHFIRE - 2050



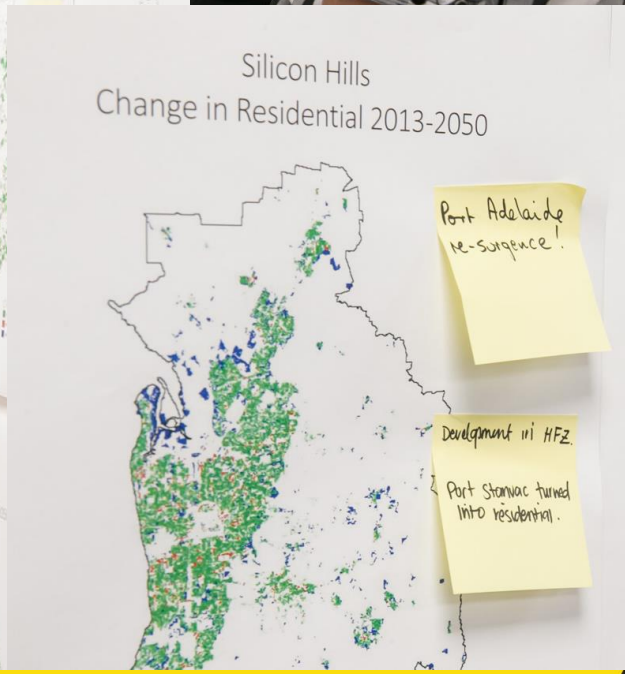
COASTAL INUNDATION - 2050



Silicon Hills – High Mitigation



Internet of Risk – Low Mitigation


Silicon Hills
Change in Residential 2013-2050
Port Adelaide re-surgence!
Development in HFZ.
Port Stanvac turned into residential.

NEXT STEPS

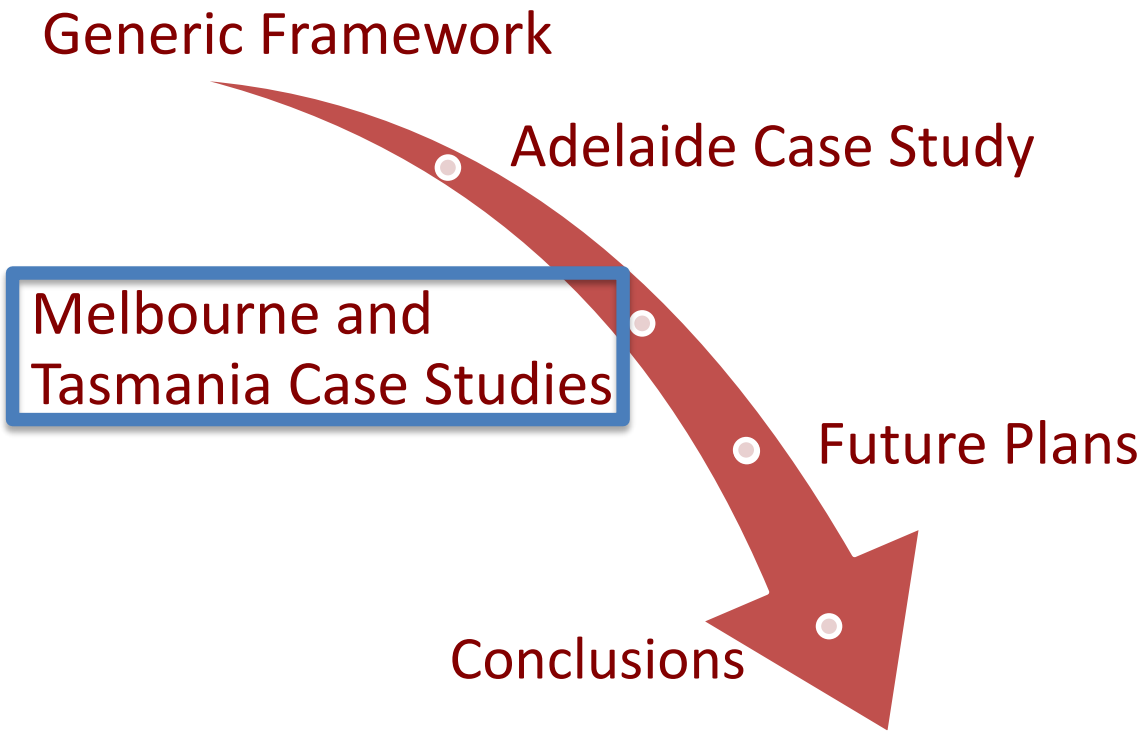
1) Refine results (linking with other CRC projects)

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



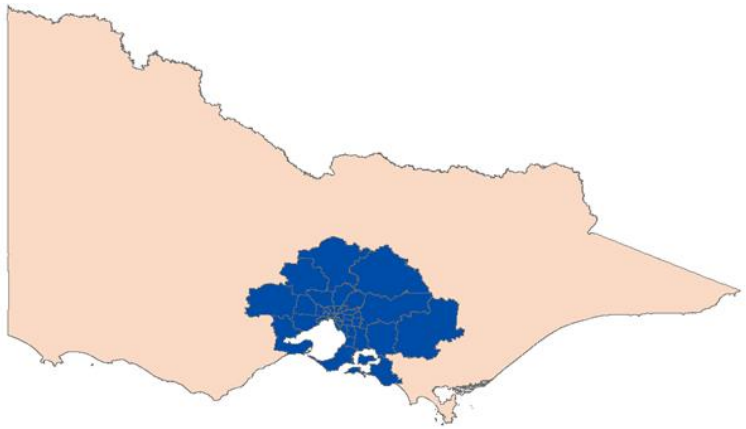


FIGURE 5: PROPOSED MODEL EXTENT

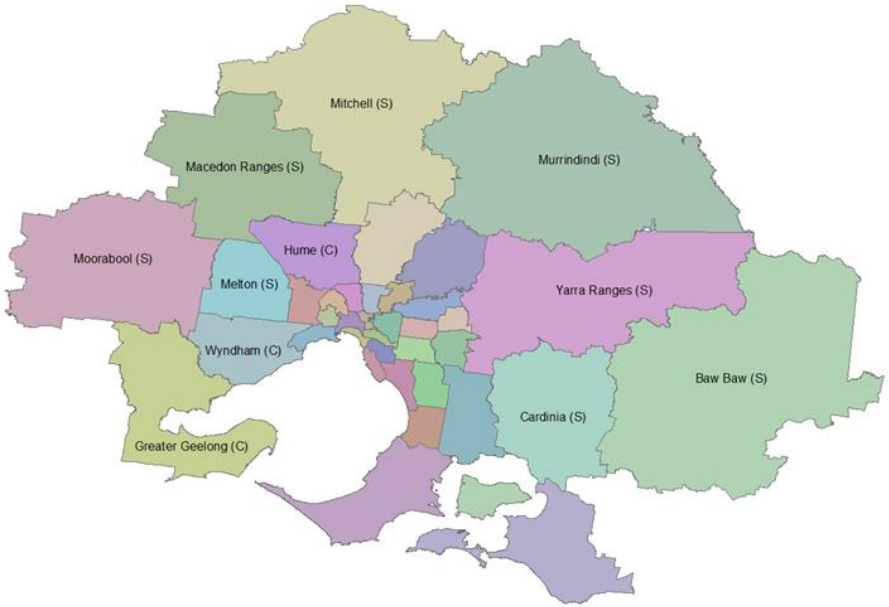
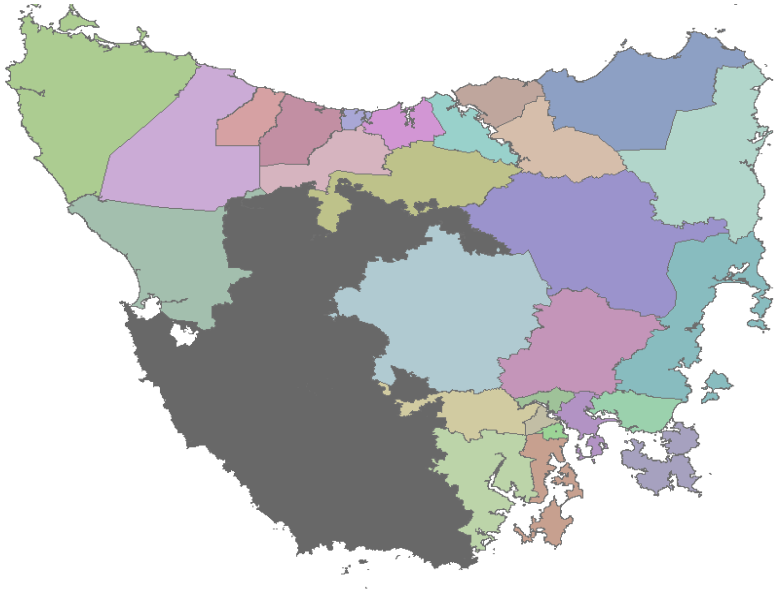


FIGURE 6: PROPOSED MODEL LGA EXTENT



MELBOURNE AND TASMANIA CASE STUDIES

First workshops held

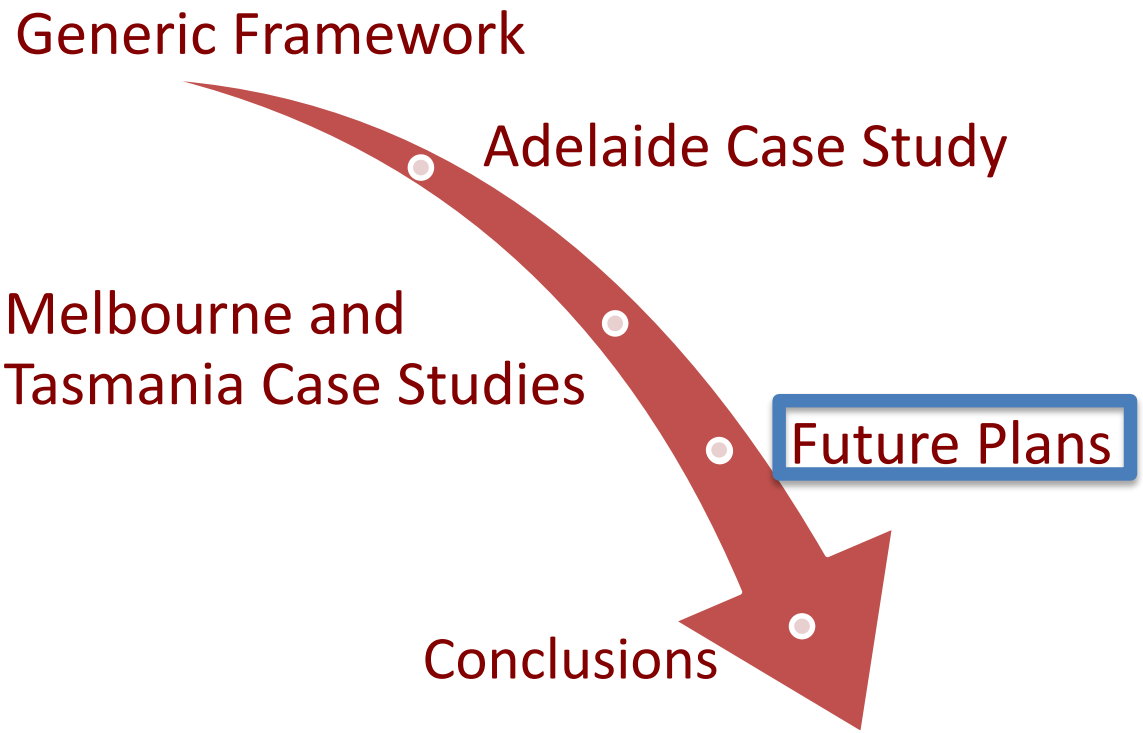
Data collection well under way

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



UTILISATION

Scoping

Function and use

- G Specified
- G Explore the risk problem
- Y Evaluate risk-reduction options
- R Make risk-reduction plans

Hazards

- O Geophysical
- R Meteorological
- G Hydrological
- O Climatalogical
- R Multi-hazard assessment

End-users and operators

- Y Reported on

Spatial and temporal information

- G Spatially explicit
- O Temporally dynamic

Problem Formulation

Risk reduction measures

- O Structural options
- R Financial instruments
- O Landuse planning
- O Natural resource management
- R Education
- Y Improved monitoring/warning /evacuation/response
- R Administrative changes

External drivers

- Y Economic
- O Environmental
- O Social
- O Built environment
- R Intangibles

Criteria

- G More than pure hazard criteria used (e.g. risk based)
- O Social
- R Technological
- G Environmental
- O Economic
- R Political

Analysis framework

Model selection

- G Hazard
- Y Exposure
- Y Vulnerability

Model integration

- Y Reported on

Evaluating mitigation options and developing plans

- R Inclusion of MCDA, Sensitivity, Uncertainty or Optimisation analysis

Legend

G Y O R

Greater coverage ⟷ Lower coverage

User and organisational interaction with the system

Specifying criteria for enduser requirements

- R Reported on deriving criteria for enduser requirements from modelling results
- O Aggregated risk into decision criteria

GUI design and development

- Y UI developed
- R Enduser engagement and consideration of different types of users

Use and user engagement

Use process

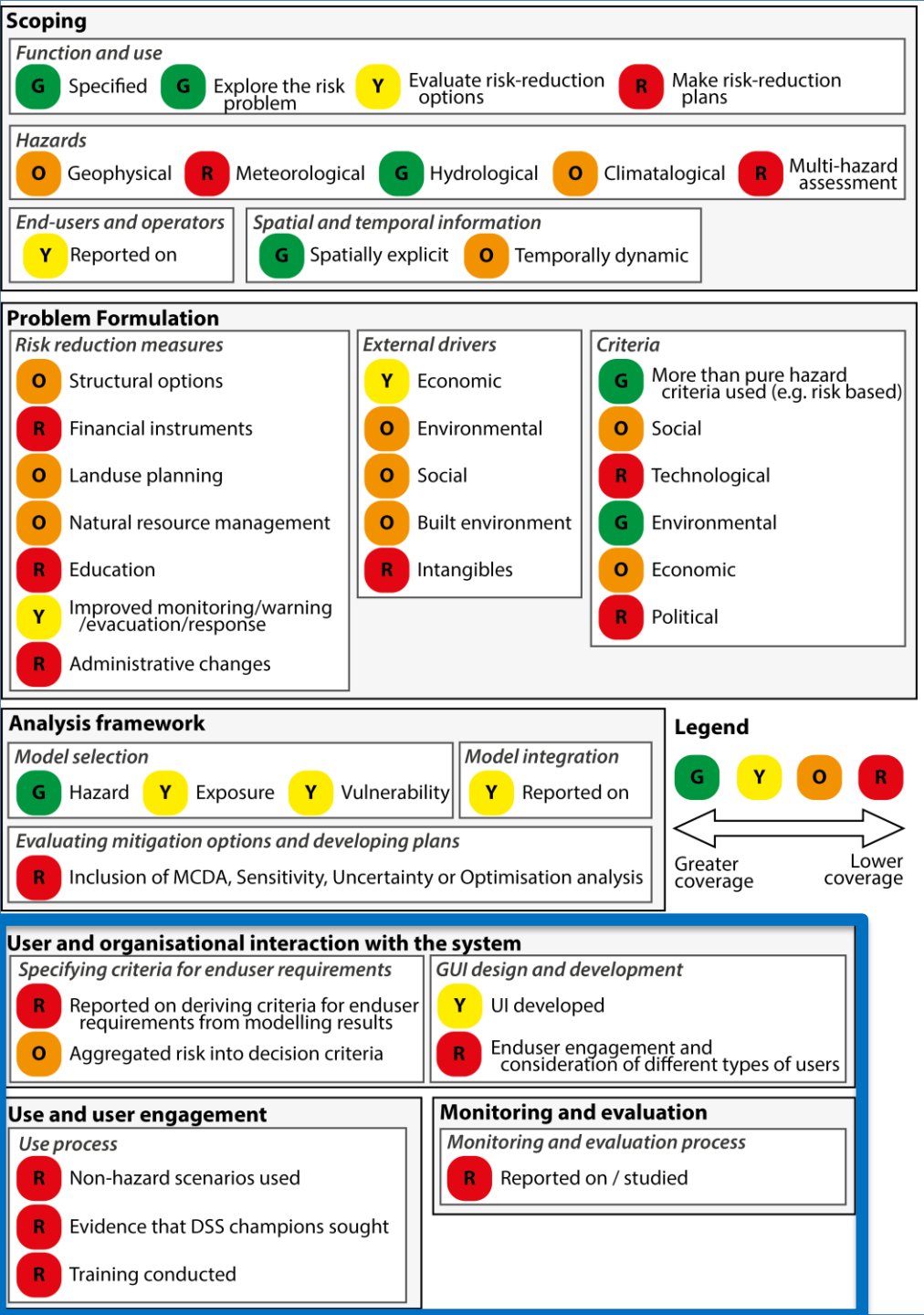
- R Non-hazard scenarios used
- R Evidence that DSS champions sought
- R Training conducted

Monitoring and evaluation

Monitoring and evaluation process

- R Reported on / studied

UTILISATION



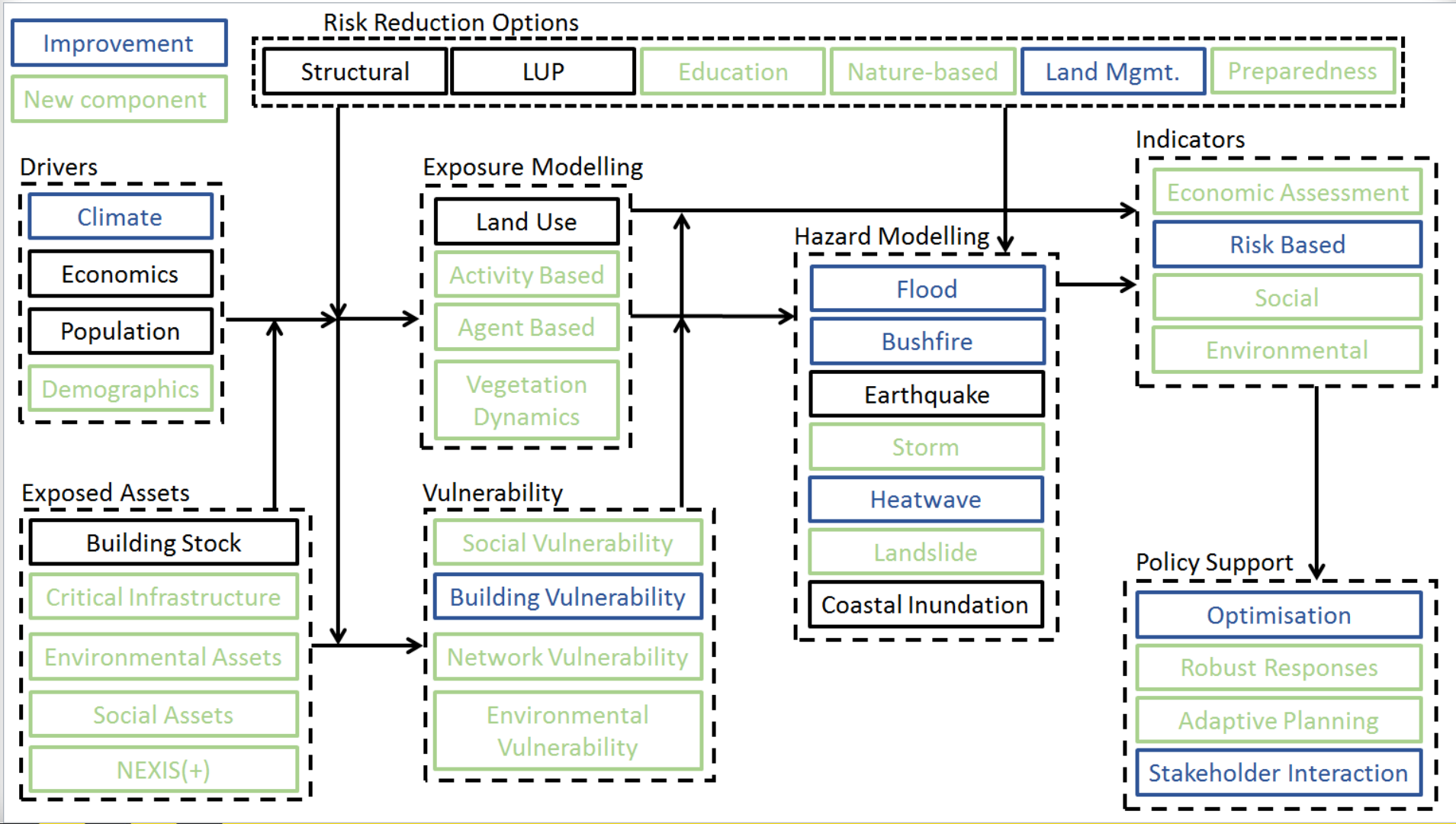
UTILISATION ACTIVITIES

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

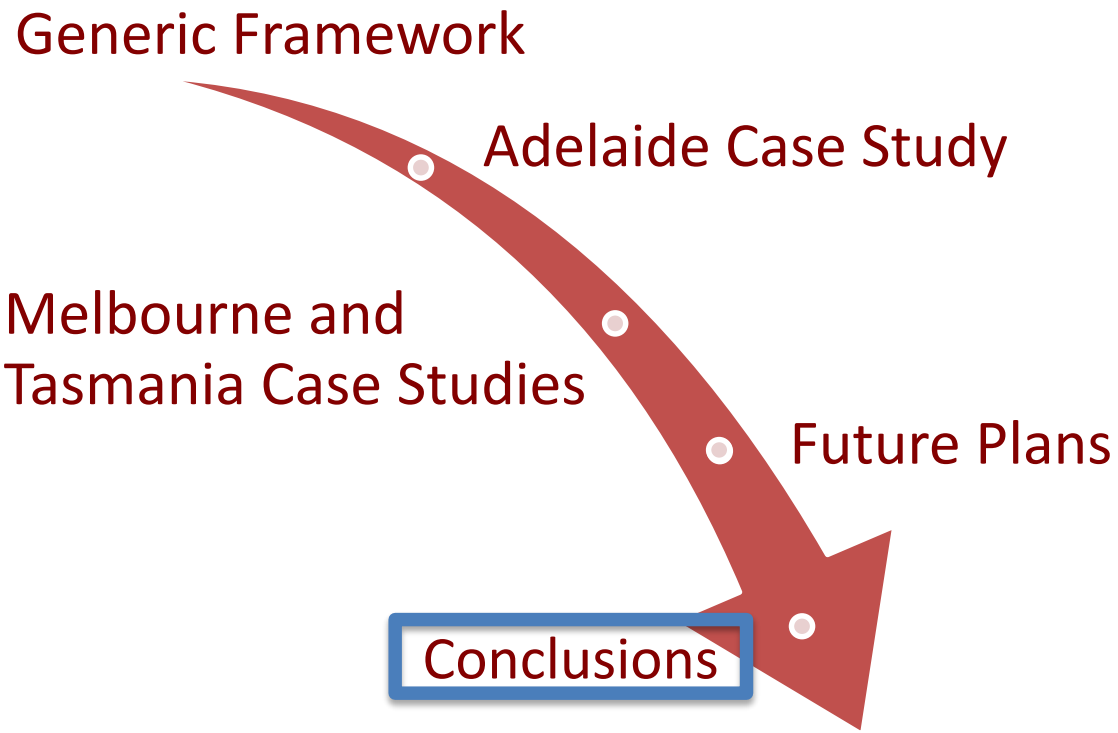
Customisation of platform for specific decision contexts
Capacity building / training / institutional arrangements

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)

RESEARCH ACTIVITIES

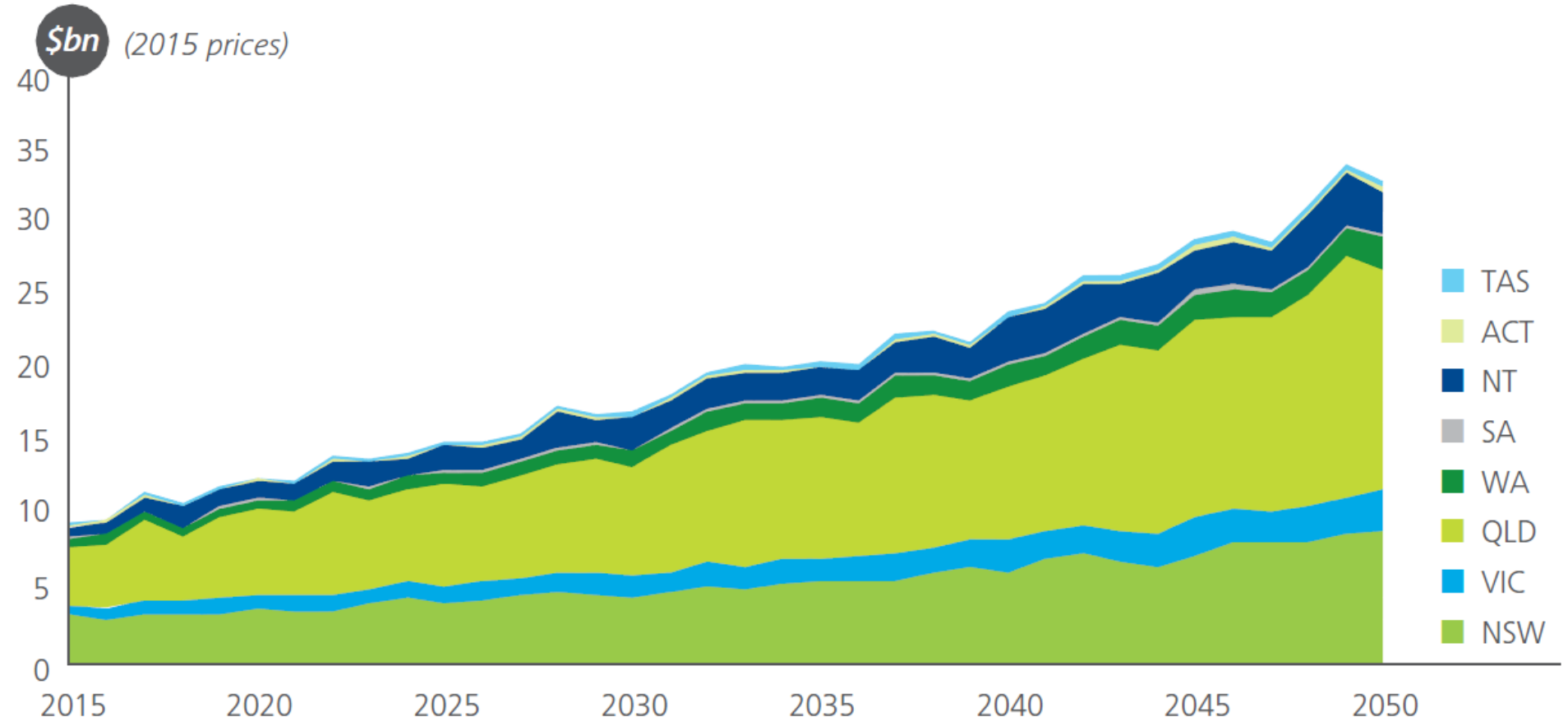


A Decision Support System for the Assessment of Policy & Planning Investment Options For Optimal Natural Hazard Mitigation



NATURAL DISASTERS *ARE* EXPENSIVE

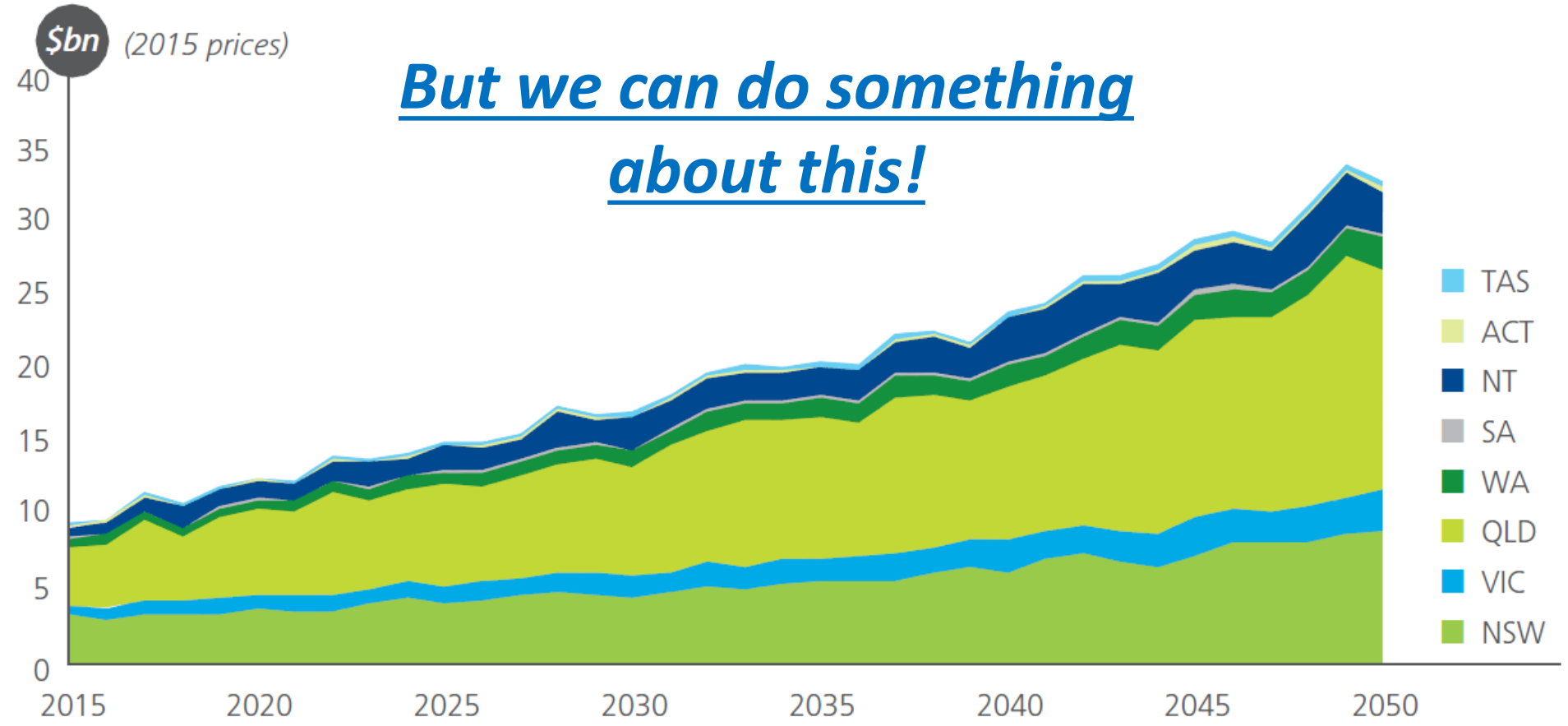
Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state



Source: Deloitte Access Economics analysis

NATURAL DISASTERS ARE EXPENSIVE

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



But we can do something about this!

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

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holger.maier@adelaide.edu.au