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

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bushfire&natural HAZARDSCRC

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

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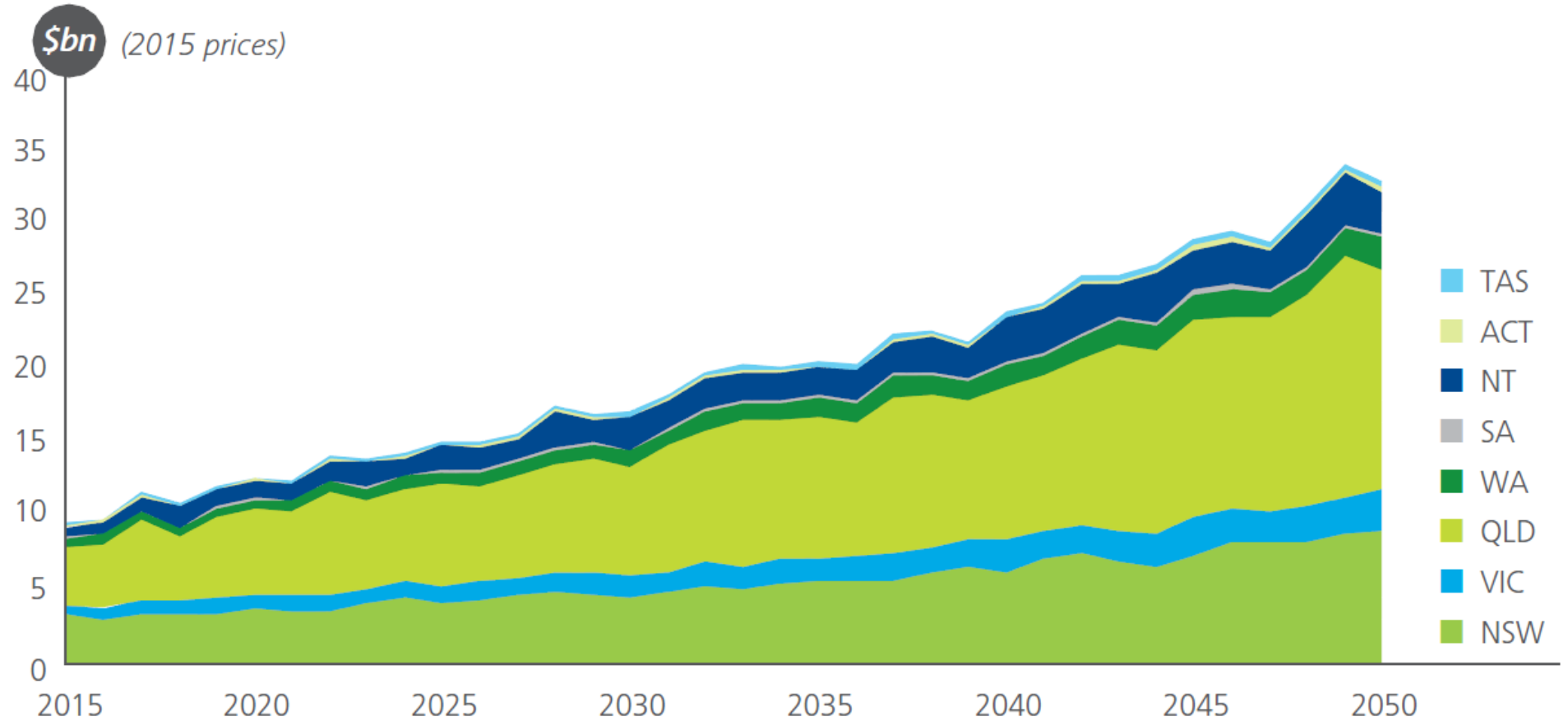
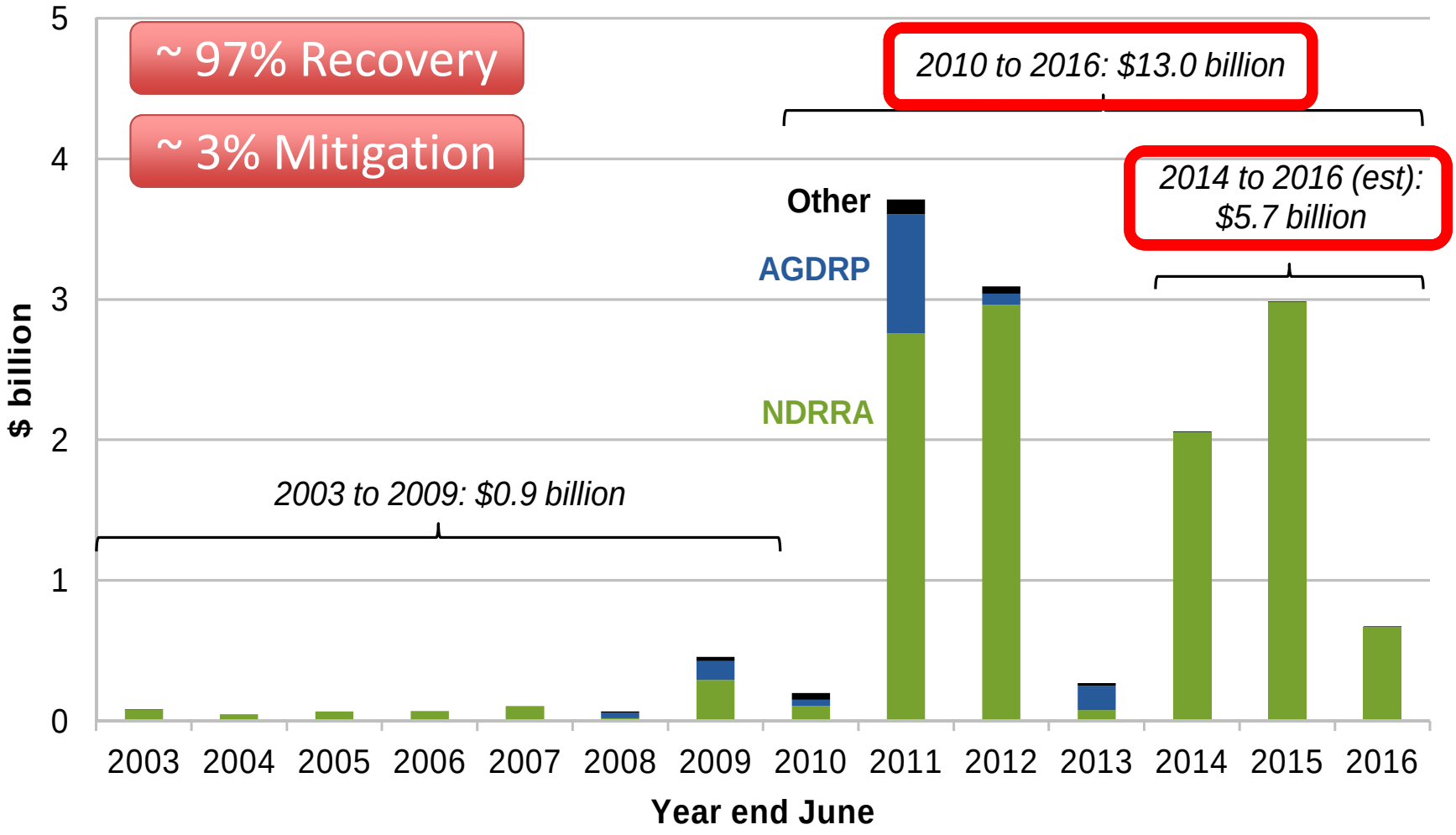
FORECAST ANNUAL COST OF NATURAL HAZARDS



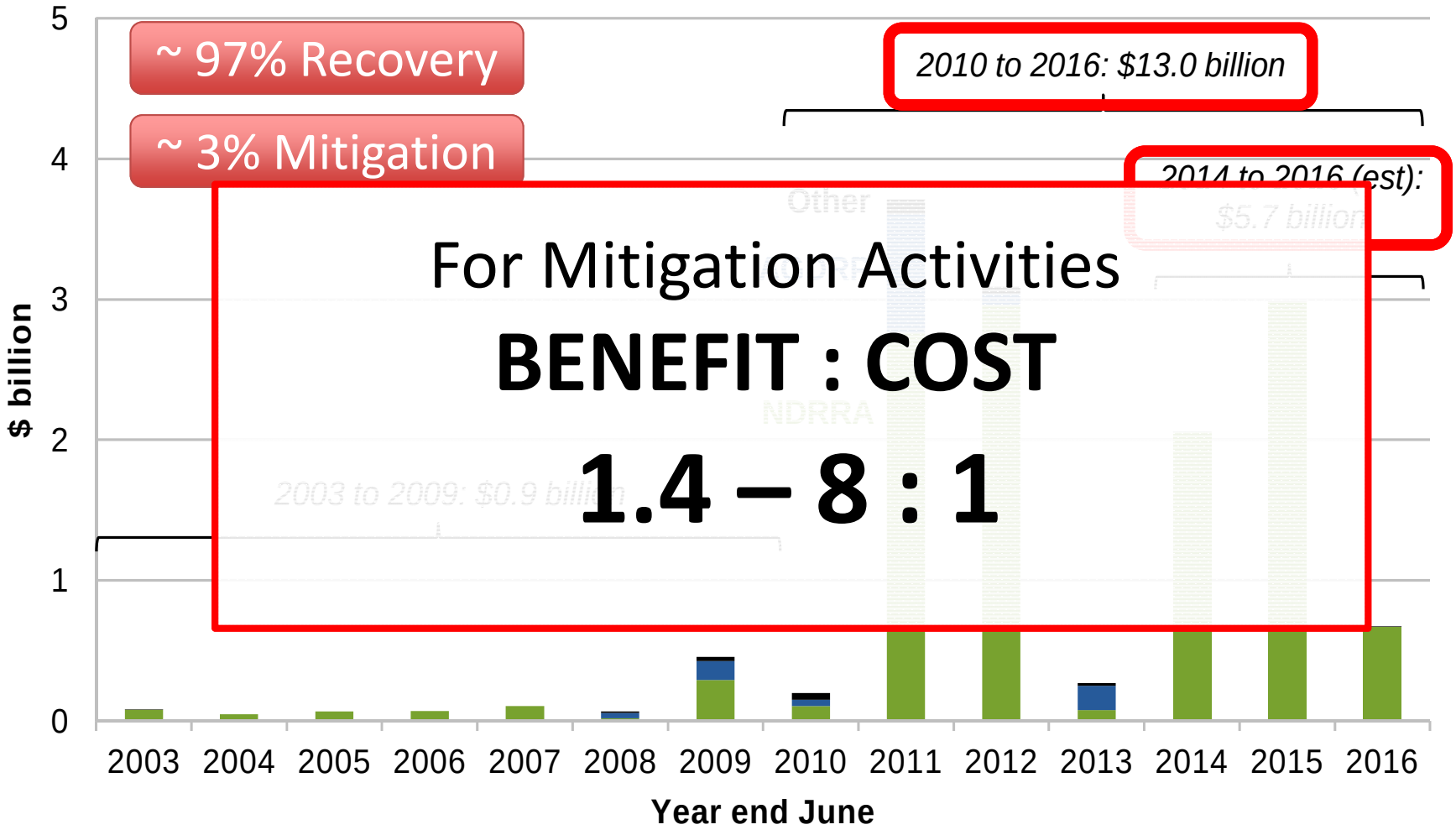
Source: Deloitte Access Economics analysis

THE MAJORITY OF SPENDING IS ON RECOVERY



(Source: Productivity Commission Draft Report)

PREVENTION IS BETTER THAN CURE



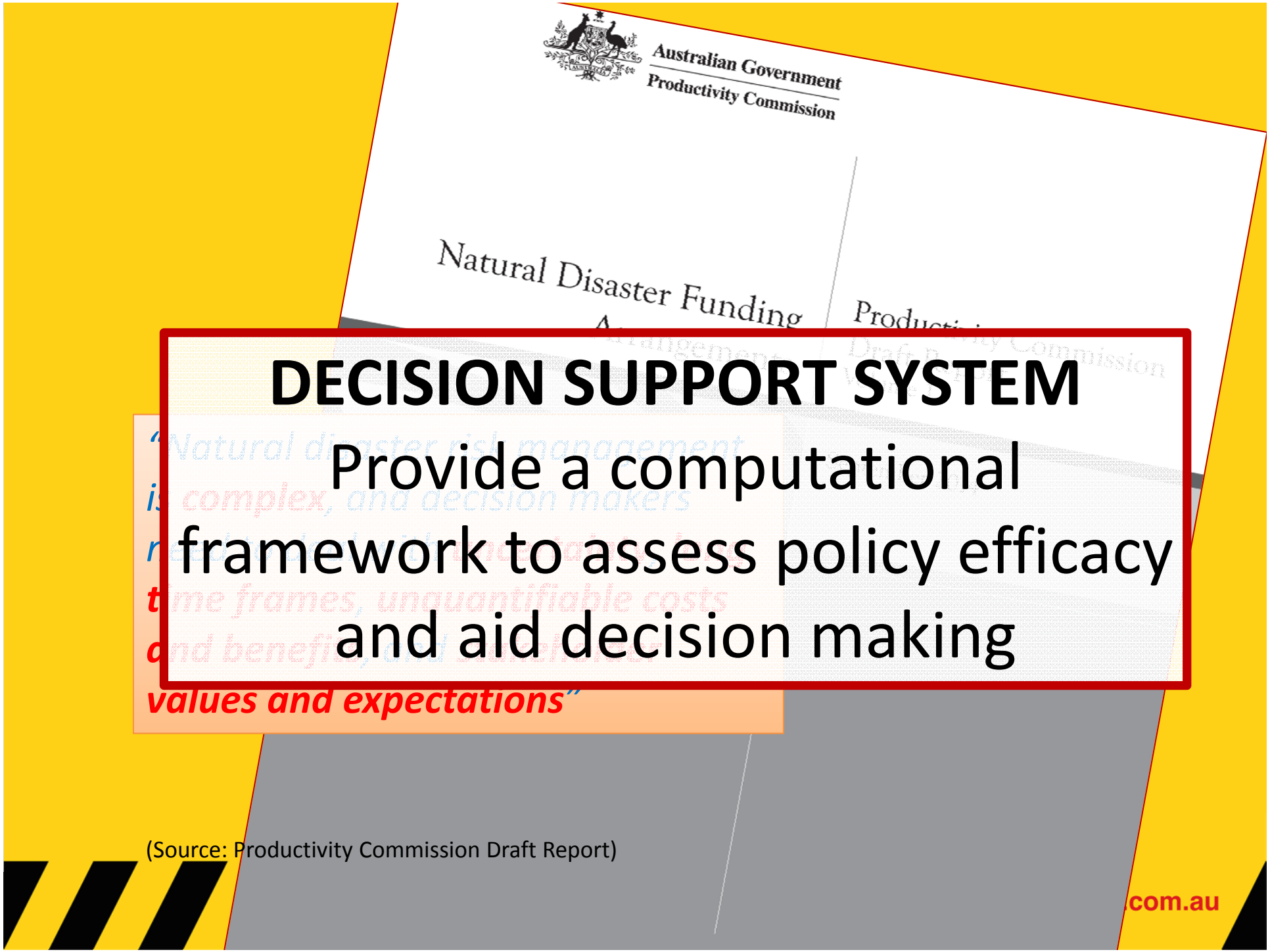
(Source: Productivity Commission Draft Report)

*"On balance, total **mitigation expenditure** across all levels of government is more likely to be **below the optimal level** than above it, given the biased incentives towards recovery under current budget treatments and funding arrangements."*

The Australian Government *"…should **increase annual mitigation expenditure gradually to $200 million**, distributed to the states and territories on a per capita basis."*

*"Natural disaster risk management is **complex**, and decision makers need to deal with **uncertainty, long time frames, unquantifiable costs and benefits**, and **stakeholder values and expectations**"*

(Source: Productivity Commission Draft Report)



DECISION SUPPORT SYSTEM

Provide a computational framework to assess policy efficacy and aid decision making

"Natural disaster risk management is complex, and decision makers ... time frames, unquantifiable costs and benefits, and differences in values and expectations"

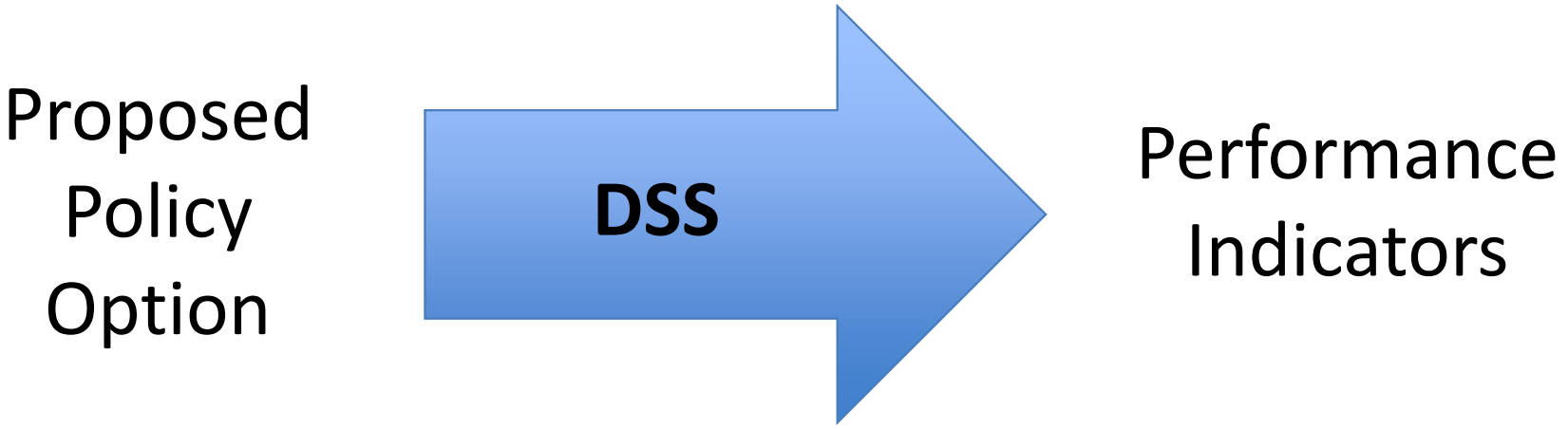
(Source: Productivity Commission Draft Report)

OVERVIEW

- Decision Support System Framework
  - Model Framework
  - Evaluation Framework
  - Software Framework
- Case-studies
  - Greater Adelaide
  - Greater Peri-Urban Melbourne
  - Tasmania
- Project Phase 2
- Future Opportunities

DECISION SUPPORT SYSTEM FRAMEWORK

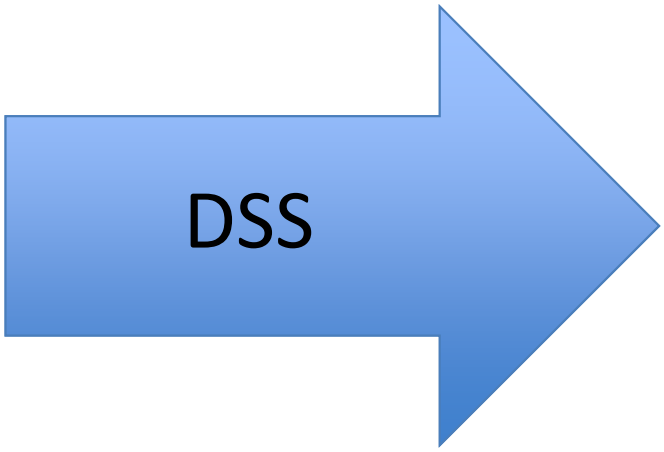
A DSS is a software tool that enables the exploration of the impacts of policy decisions



DECISION SUPPORT SYSTEM FRAMEWORK

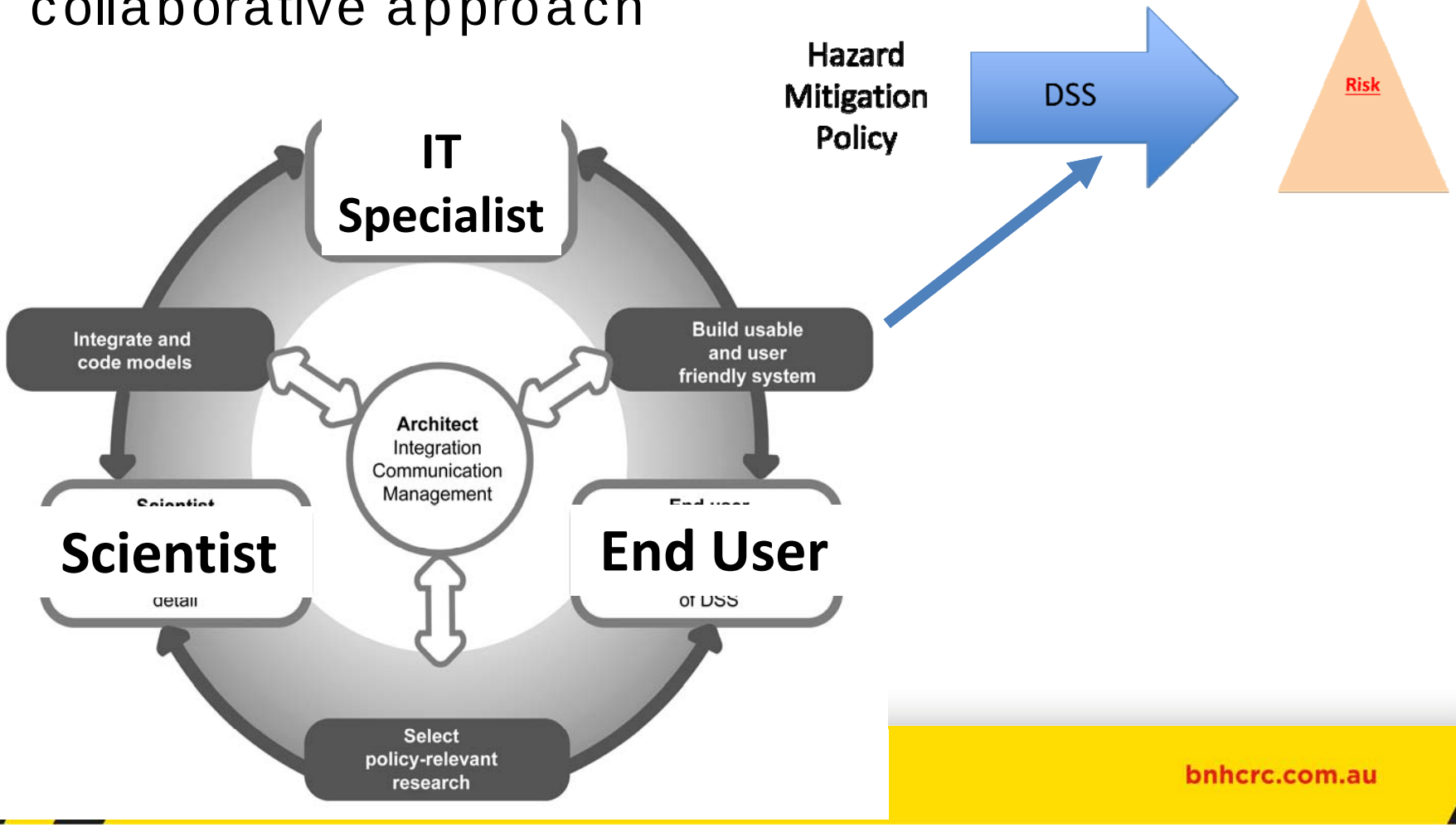
A DSS is a software tool that enables the exploration of the impacts of policy decisions

Hazard
Impact
Mitigation
Policy



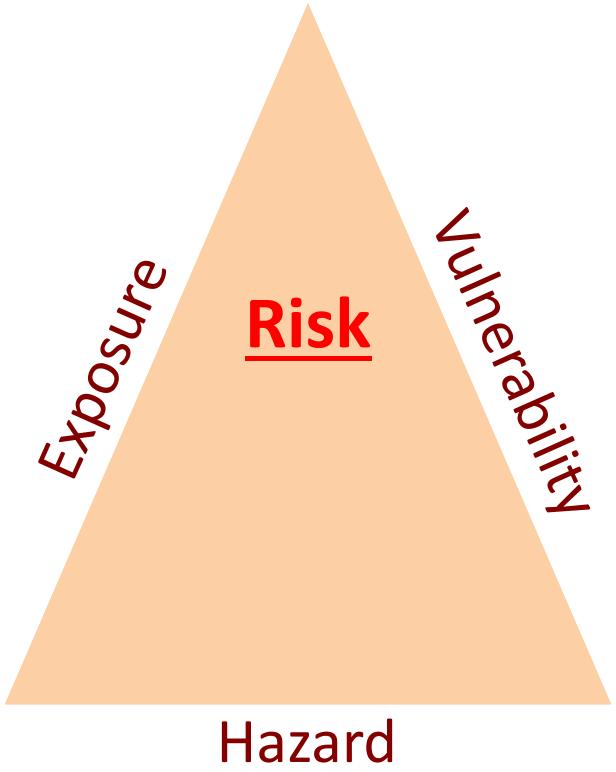
DECISION SUPPORT SYSTEM FRAMEWORK

Complexity of problem necessitates a collaborative approach



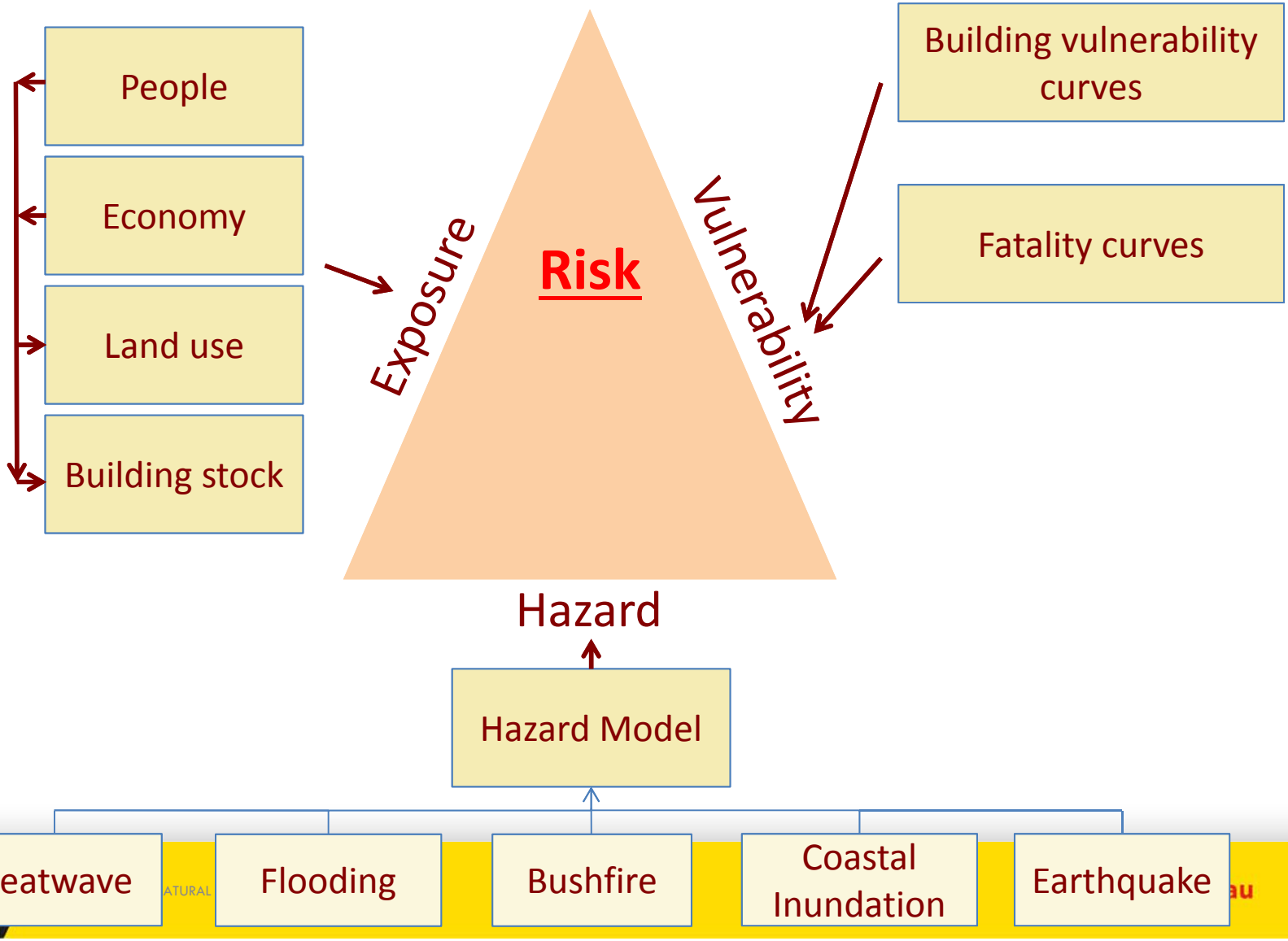
DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK



DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

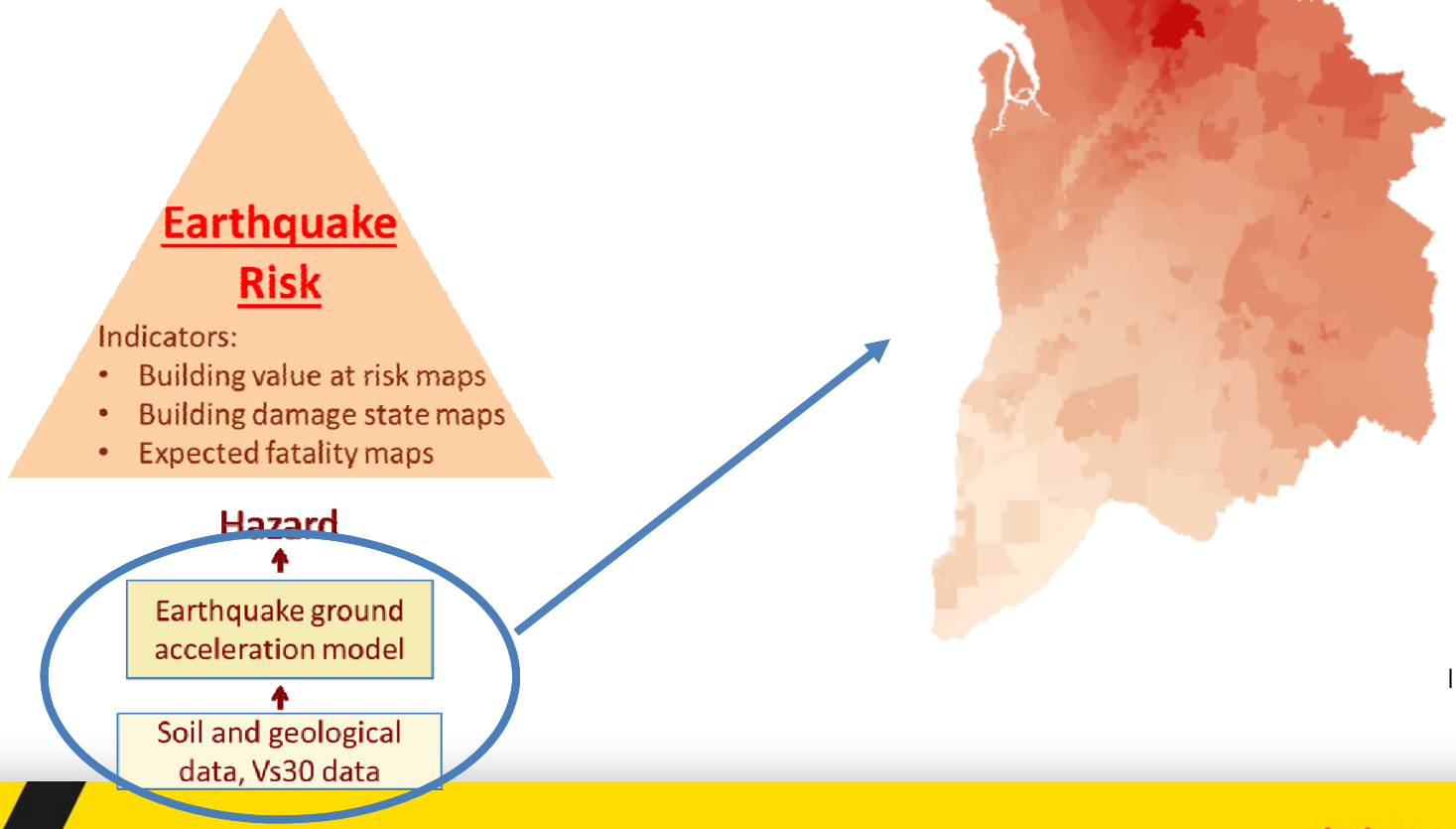


DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

Hazard Modelling

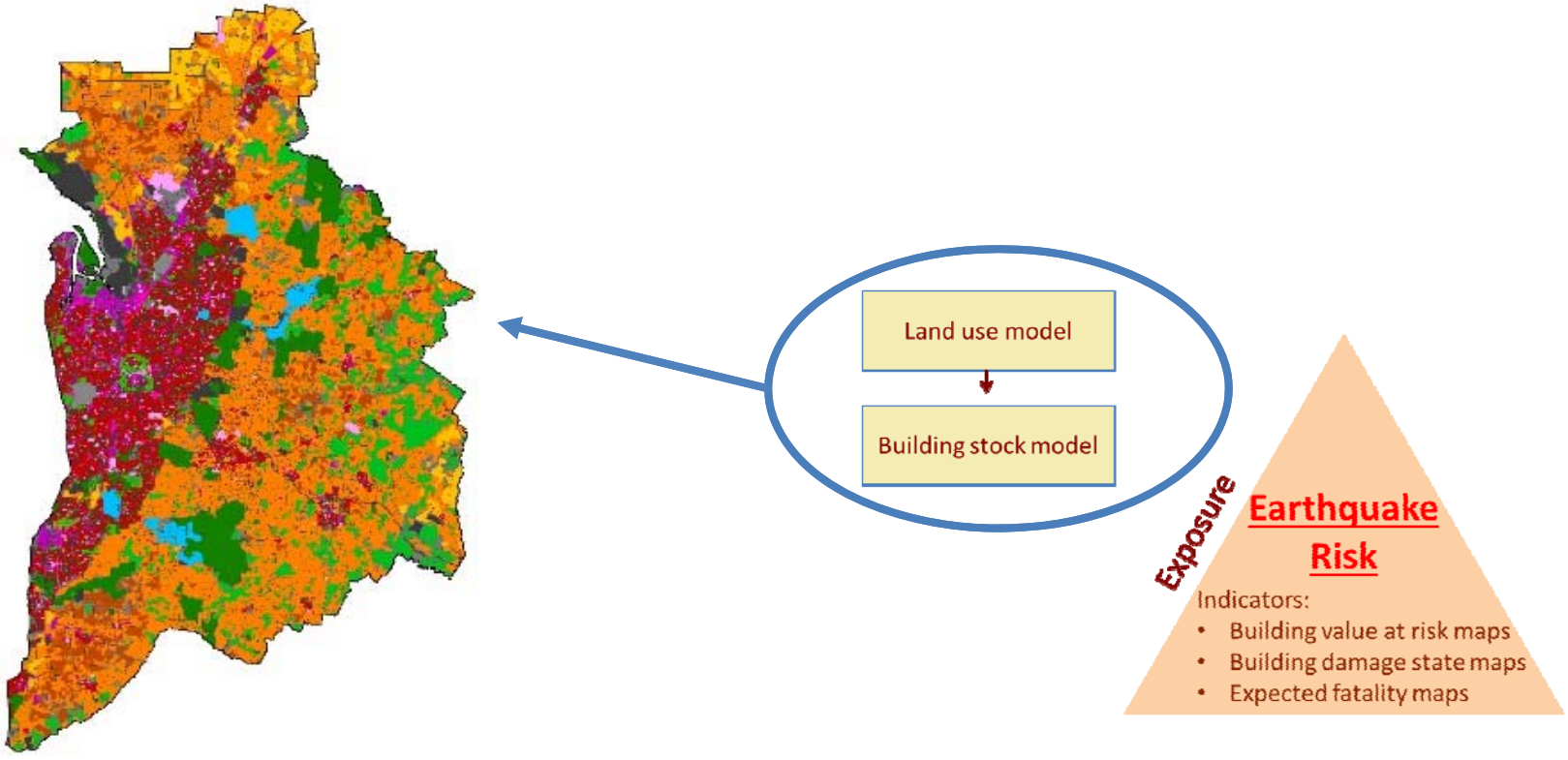
(e.g. earthquake)



DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

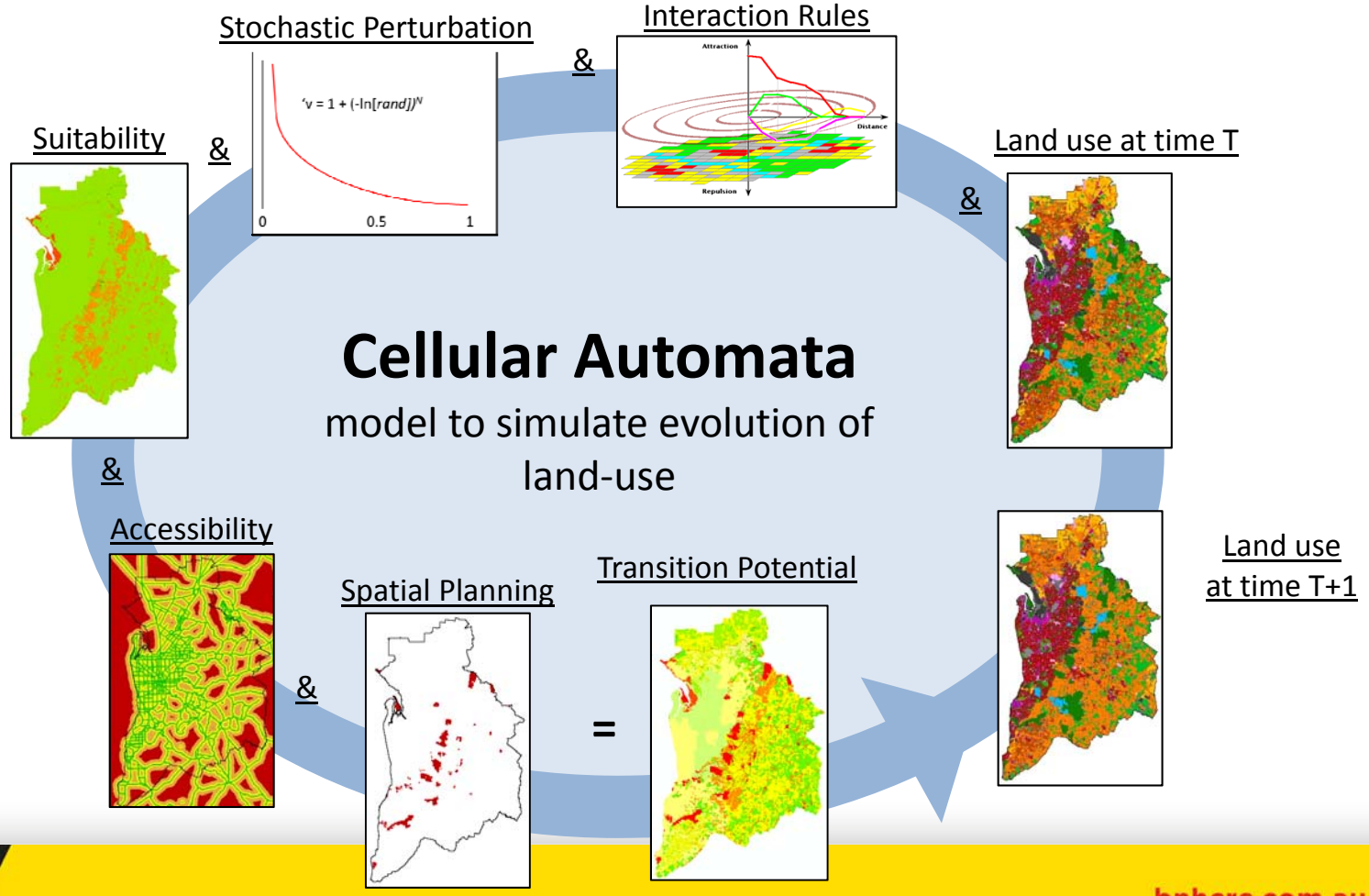
Exposure Model: Land use and associated building stock



DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

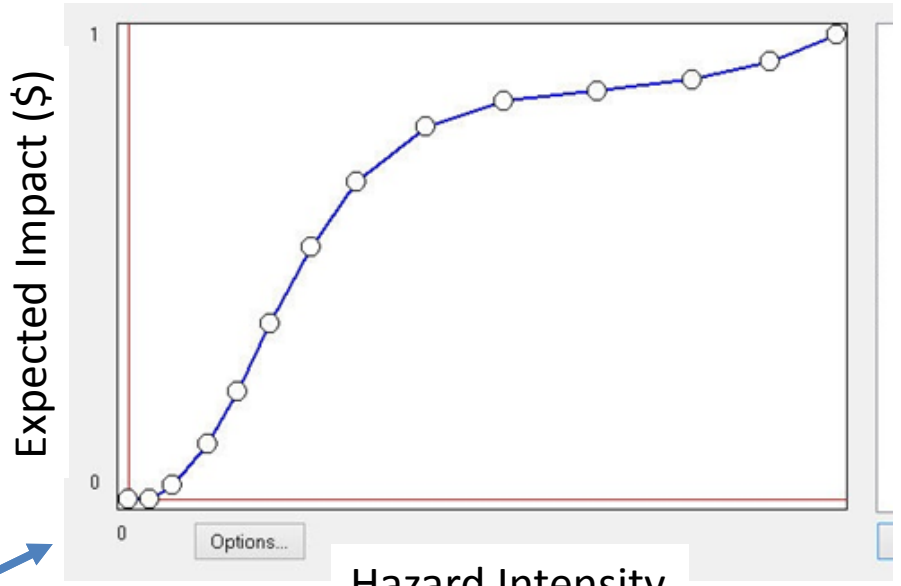
Exposure Model

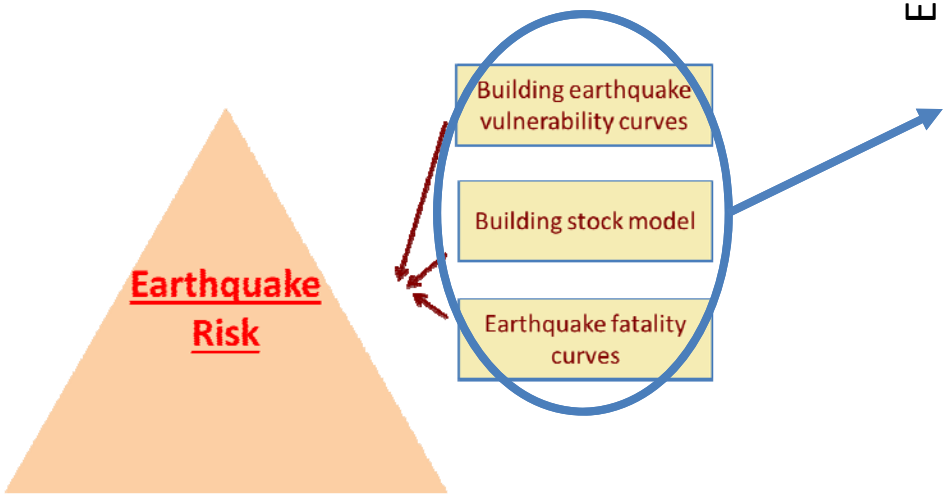


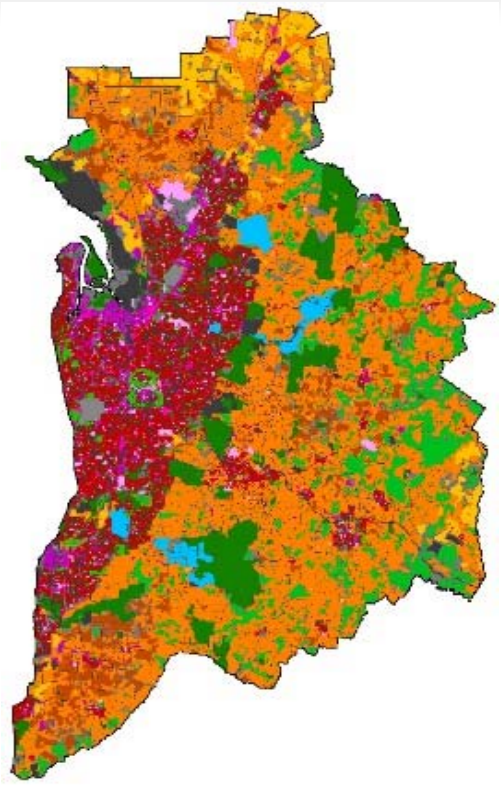
DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

Vulnerability Modelling
(Vulnerability Curves)







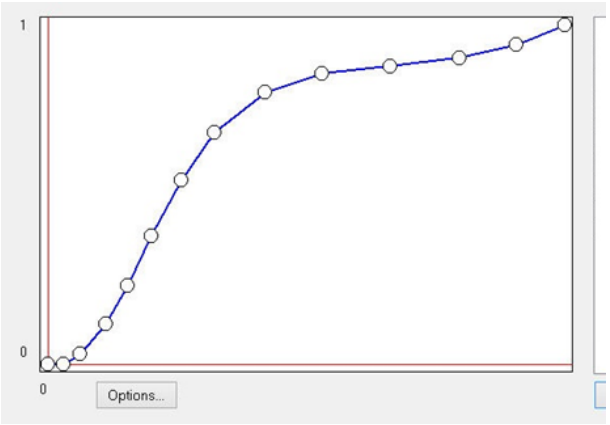
Exposure

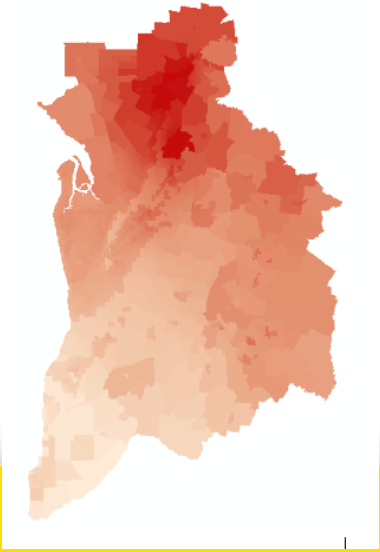
Vulnerability

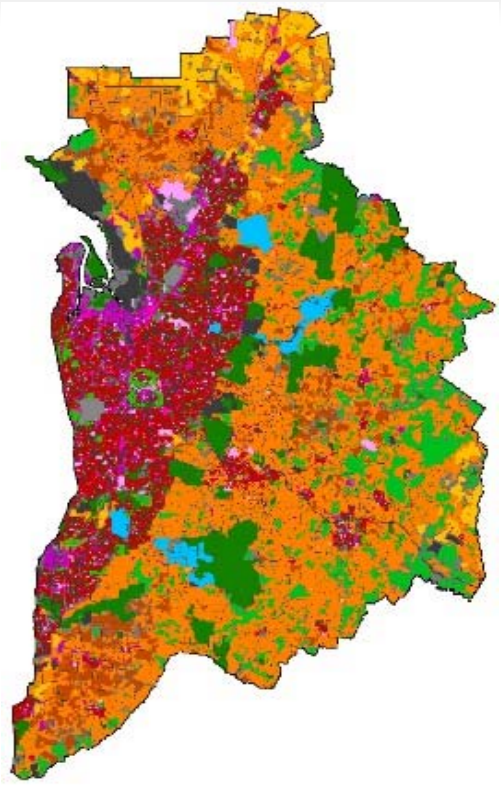
Earthquake Risk

Indicators:

- Building value at risk maps
- Building damage state maps
- Expected fatality maps



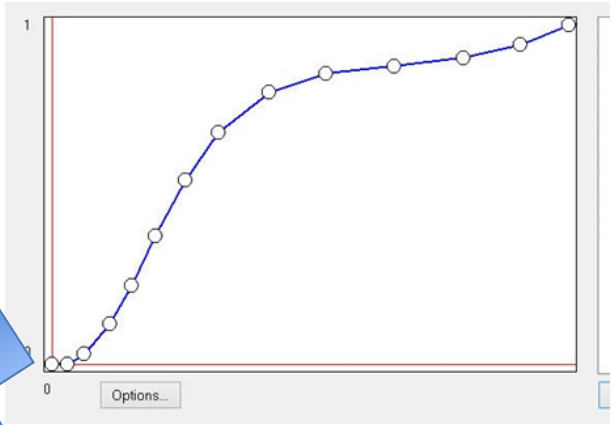




Exposure

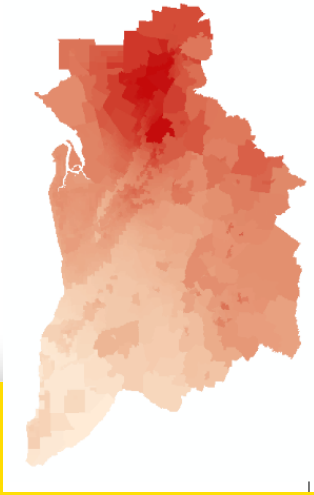
Risk

Indi
- B maps
- B ce maps
- E ps



Vulnerability

Hazard



DECISION SUPPORT SYSTEM FRAMEWORK

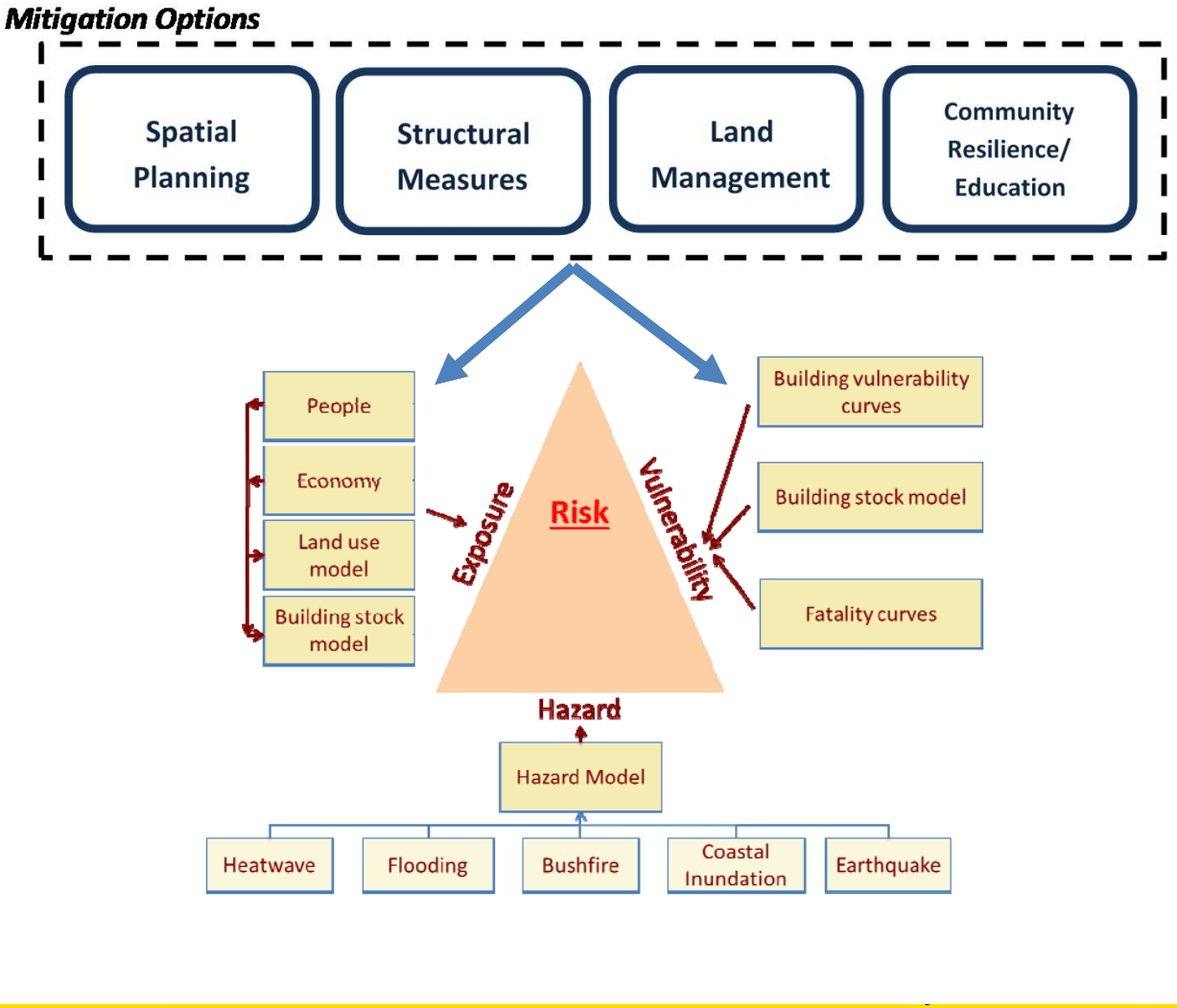
MODEL FRAMEWORK:

More General Array of indicators considered:

- Risk
  - Average annual loss: Map + Table with total per LGA
  - Number of fatalities / casualties: Map + Table with total per LGA
- Cost benefit analysis
  - Cost of mitigation options selected
  - Reduction in average annual loss from a reference base
- Social impacts
  - Side effects of mitigation options, e.g. land use planning impacts on average distance from residential locations to CBD, services and recreation
- Environmental impacts
  - Side effects of mitigation options, e.g. land use planning impacts on total natural area and connectivity of natural area

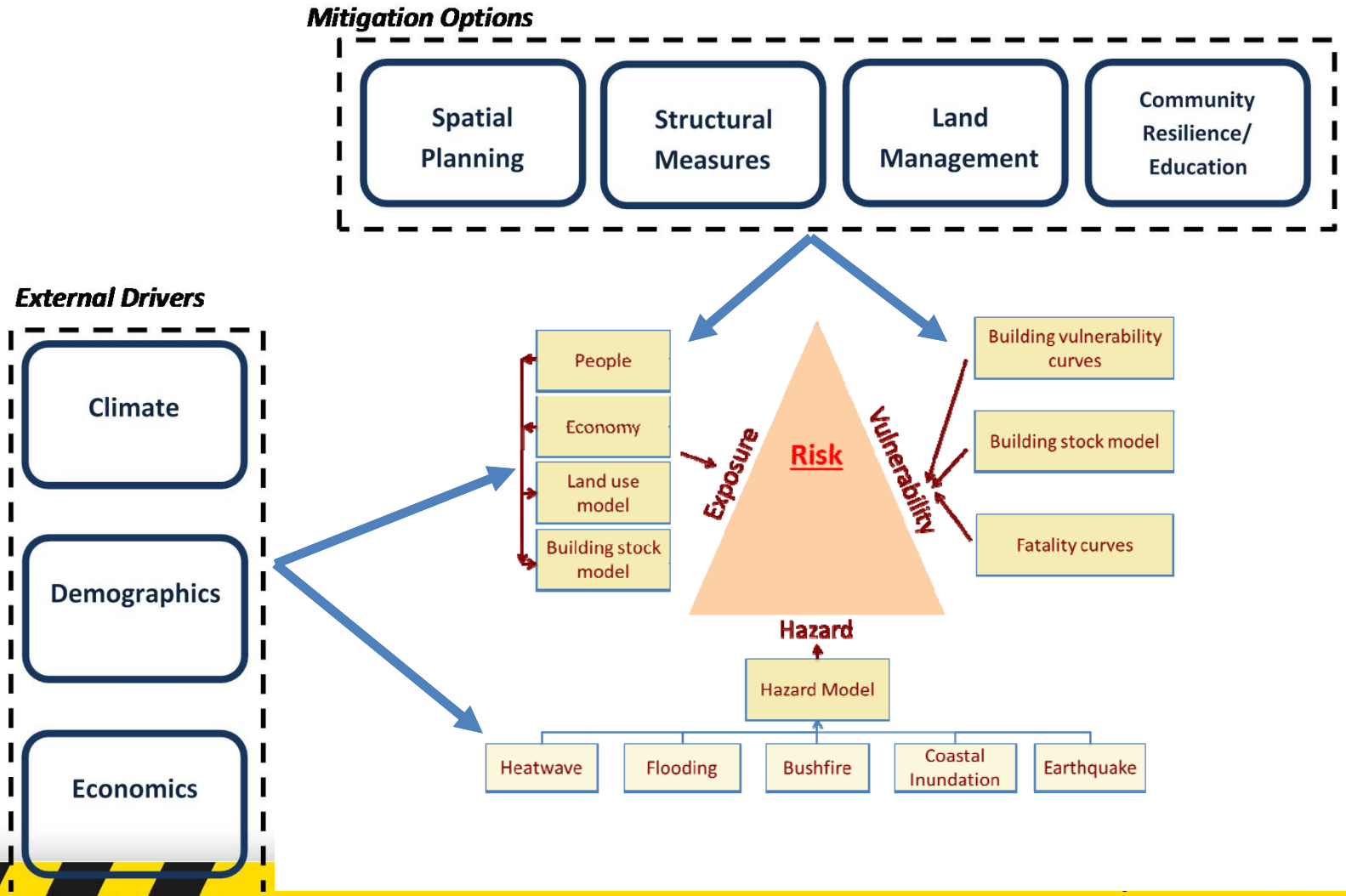
DECISION SUPPORT SYSTEM FRAMEWORK

EVALUATION FRAMEWORK



DECISION SUPPORT SYSTEM FRAMEWORK

EVALUATION FRAMEWORK



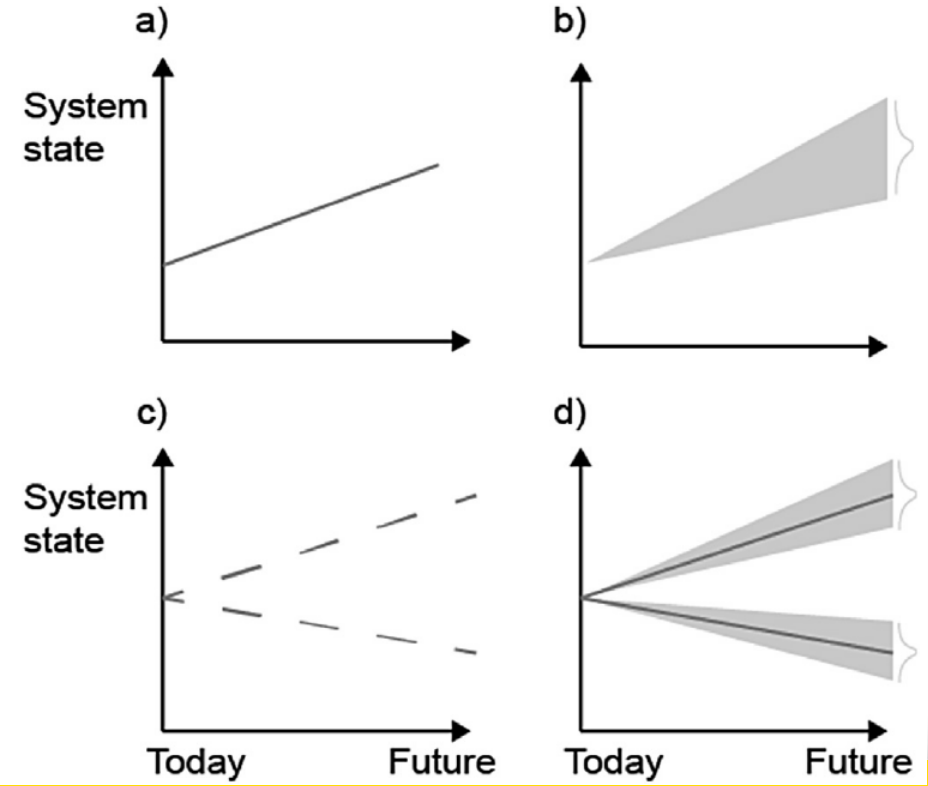
DECISION SUPPORT SYSTEM FRAMEWORK

EVALUATION FRAMEWORK

Deep uncertainty in external drivers necessitates an *exploratory scenario* based approach:

What are plausible futures for the drivers?:

- Climate
- Demographics
- Economy



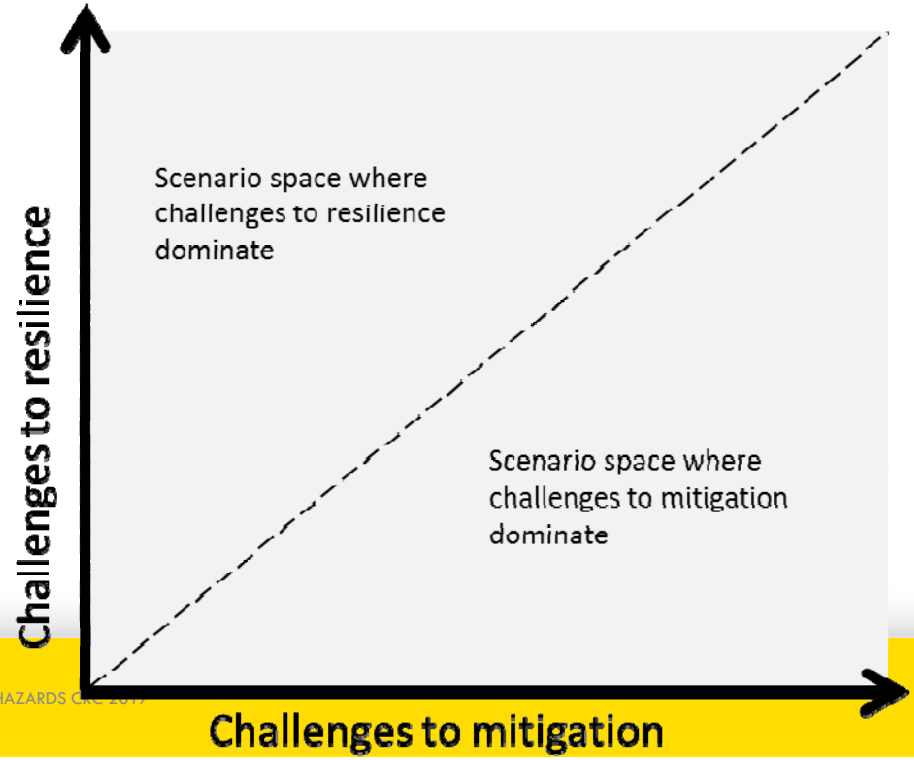
DECISION SUPPORT SYSTEM FRAMEWORK

EVALUATION FRAMEWORK

Scenario framing around challenges to policy efficacy

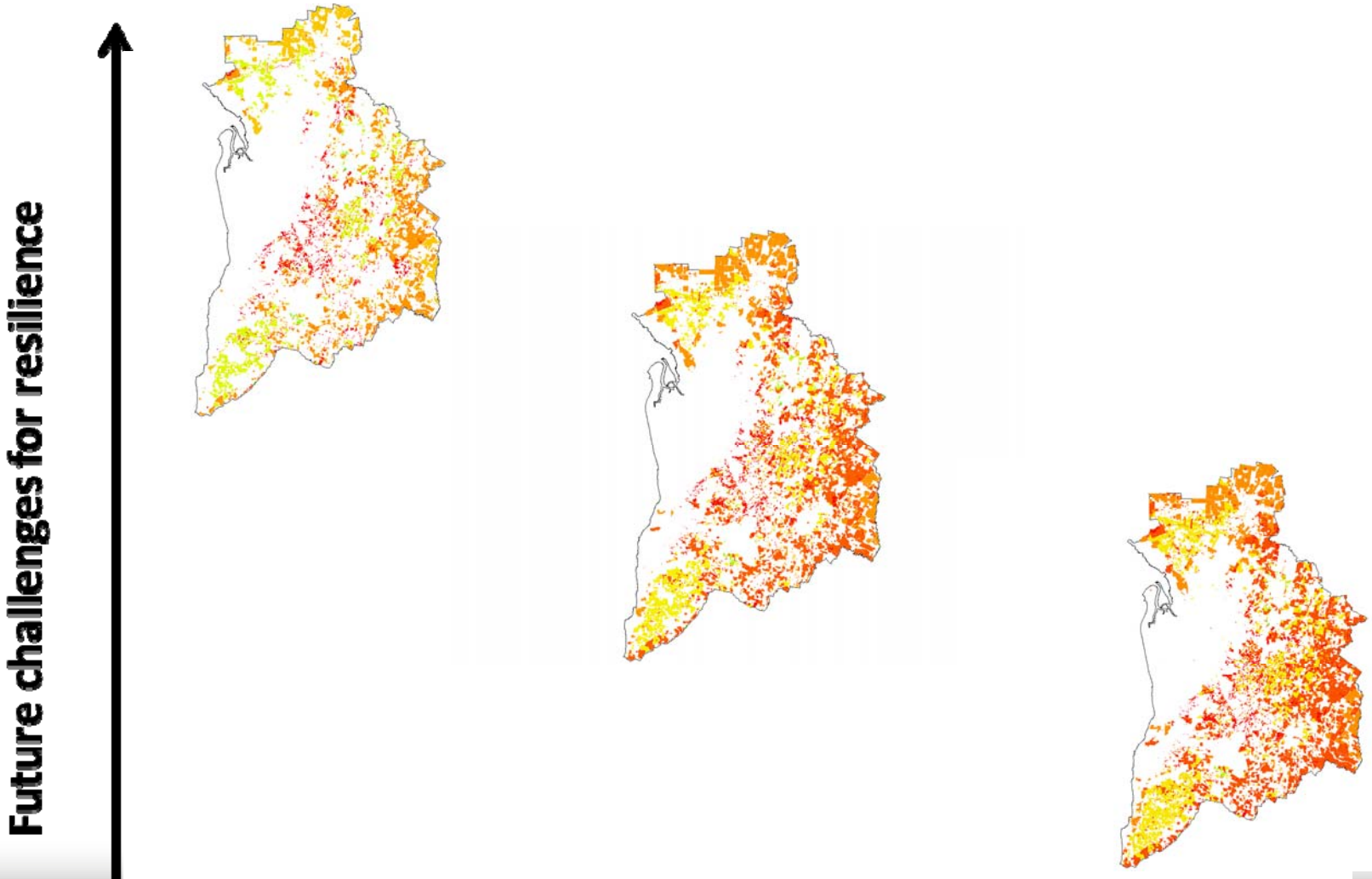
What driver trends present challenges for:

- *Community resilience initiatives*
- *Government mitigation policy interventions*



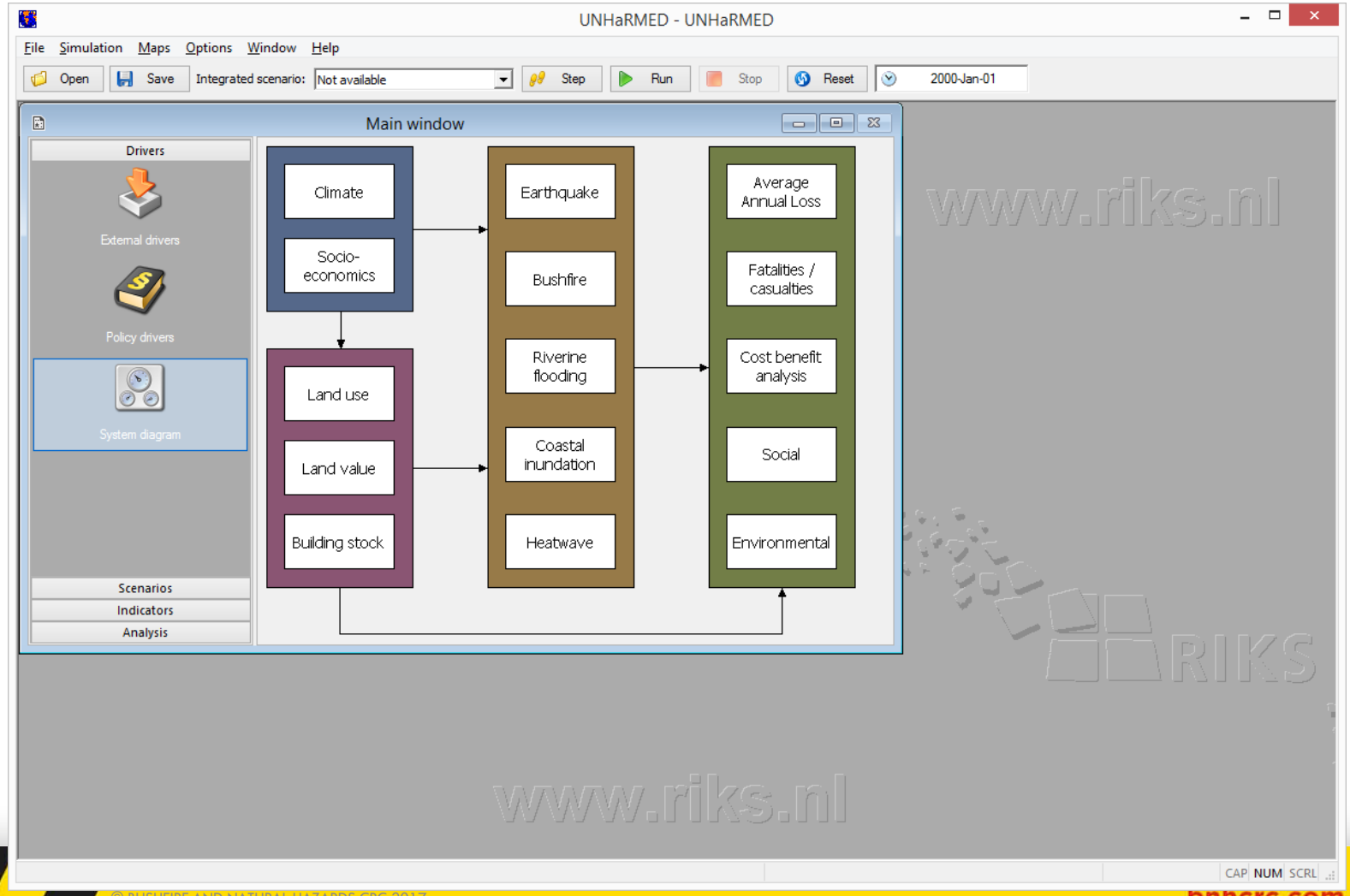
DECISION SUPPORT SYSTEM FRAMEWORK

EVALUATION FRAMEWORK



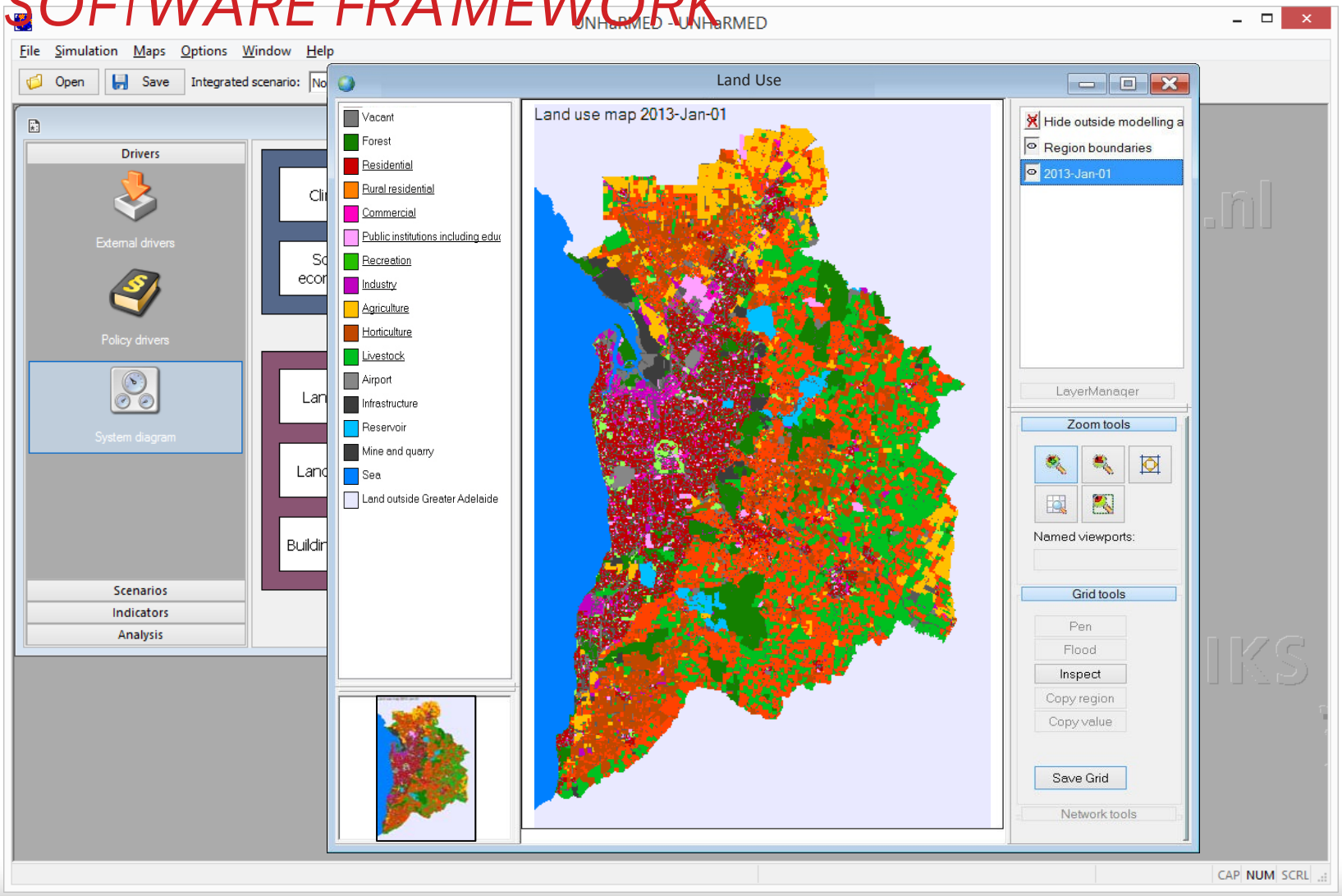
DECISION SUPPORT SYSTEM FRAMEWORK

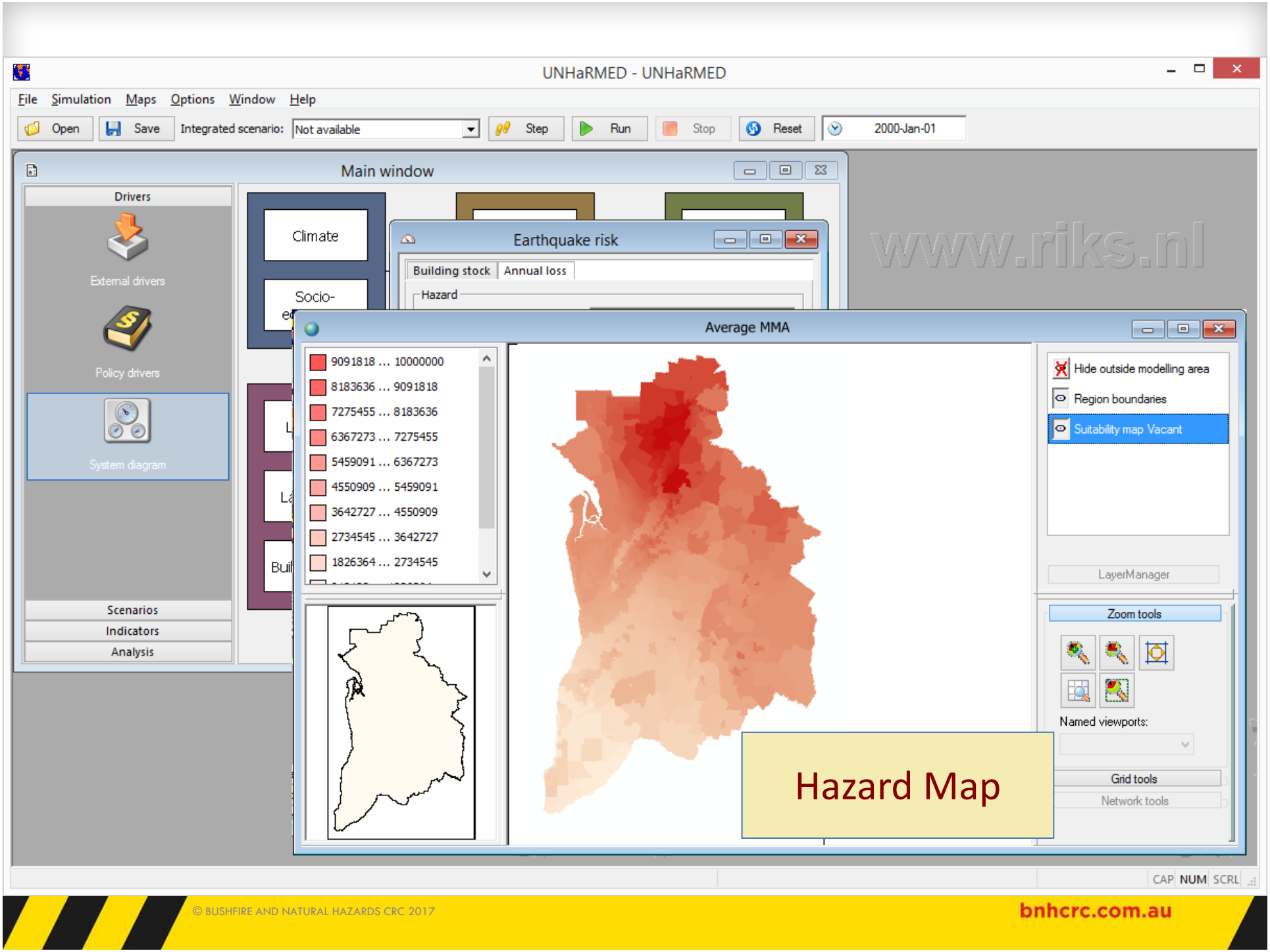
SOFTWARE FRAMEWORK



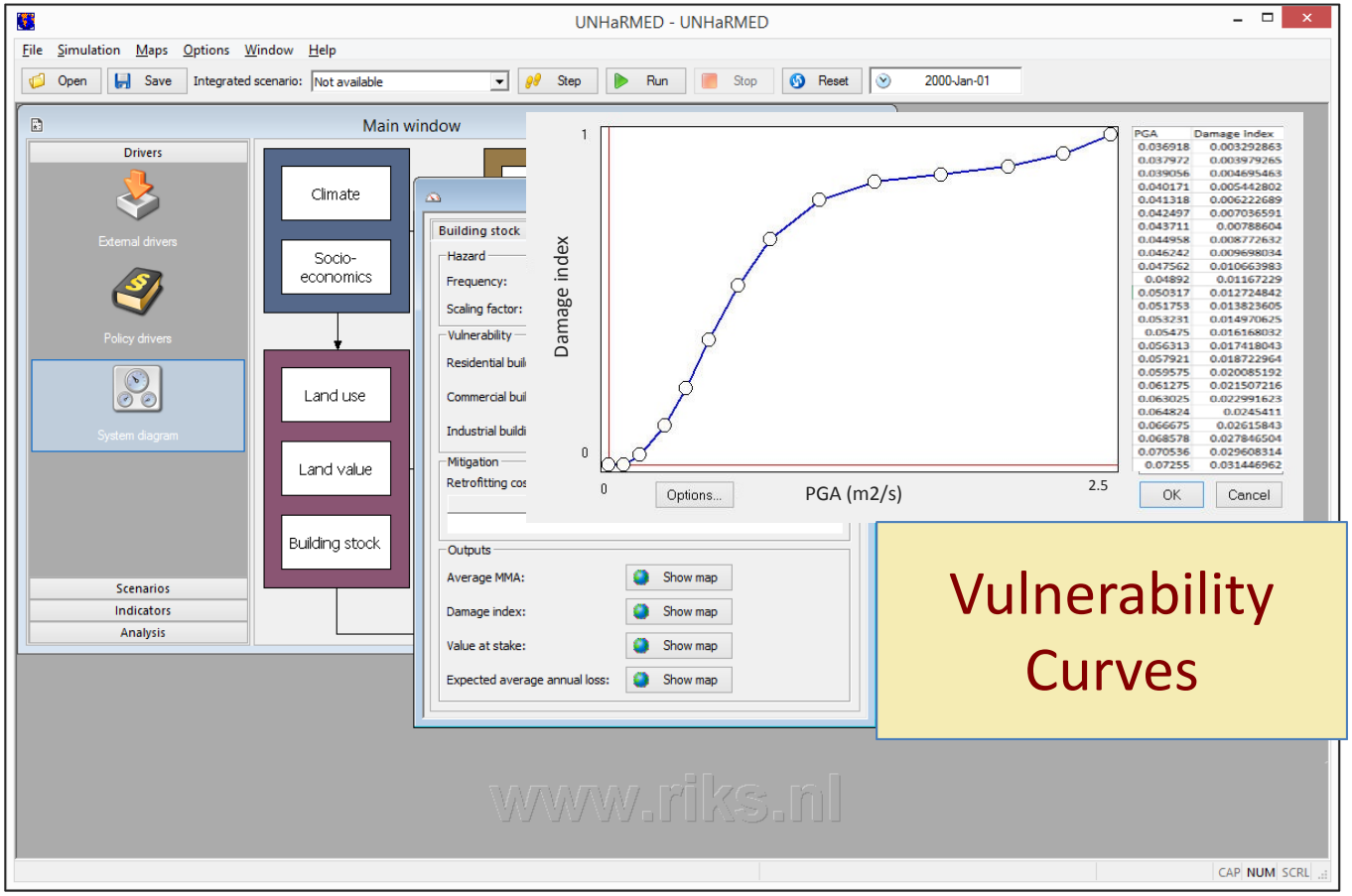
DECISION SUPPORT SYSTEM FRAMEWORK

SOFTWARE FRAMEWORK

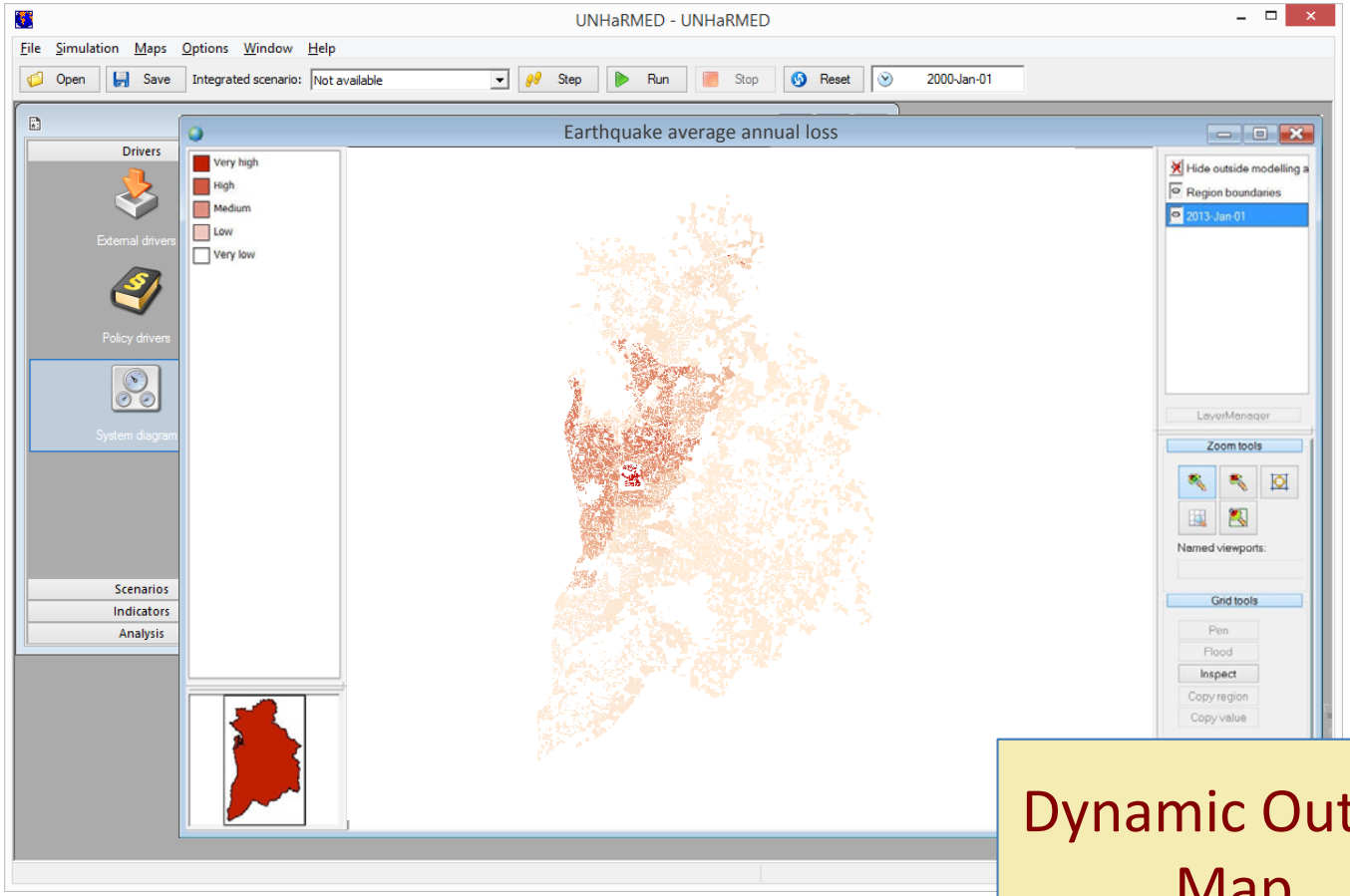




EARTHQUAKE

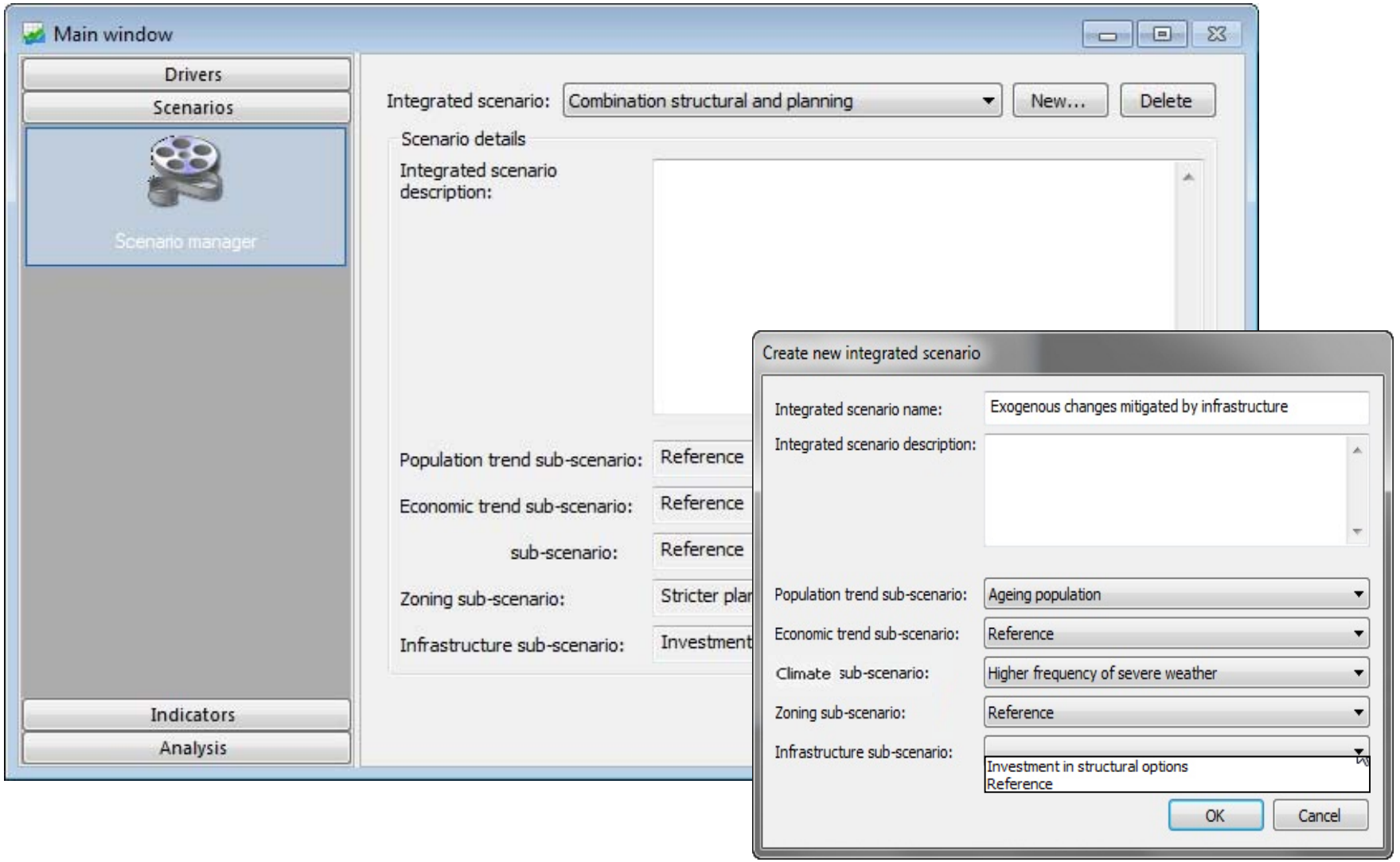


EARTHQUAKE



Dynamic Output Map

SCENARIO ANALYSIS

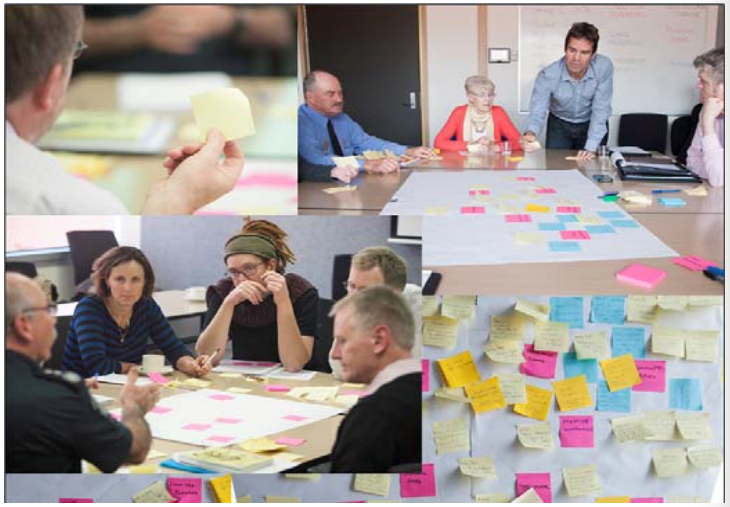


CASE STUDIES
APPROACH

- Phase 1 – Scoping
  - Region and extent of DSS
  - Key Hazards
  - Identification of mitigation options
  - Indicators of Risk
- Phase 2 – Qualitative scenario development
  - Key drivers of change and major uncertainties
  - Factors effecting resilience of mitigation
- Phase 3 – Quantitative scenario development
- Phase 4 – Development of optimisation approach

CASE STUDIES
GREATER ADELAIDE

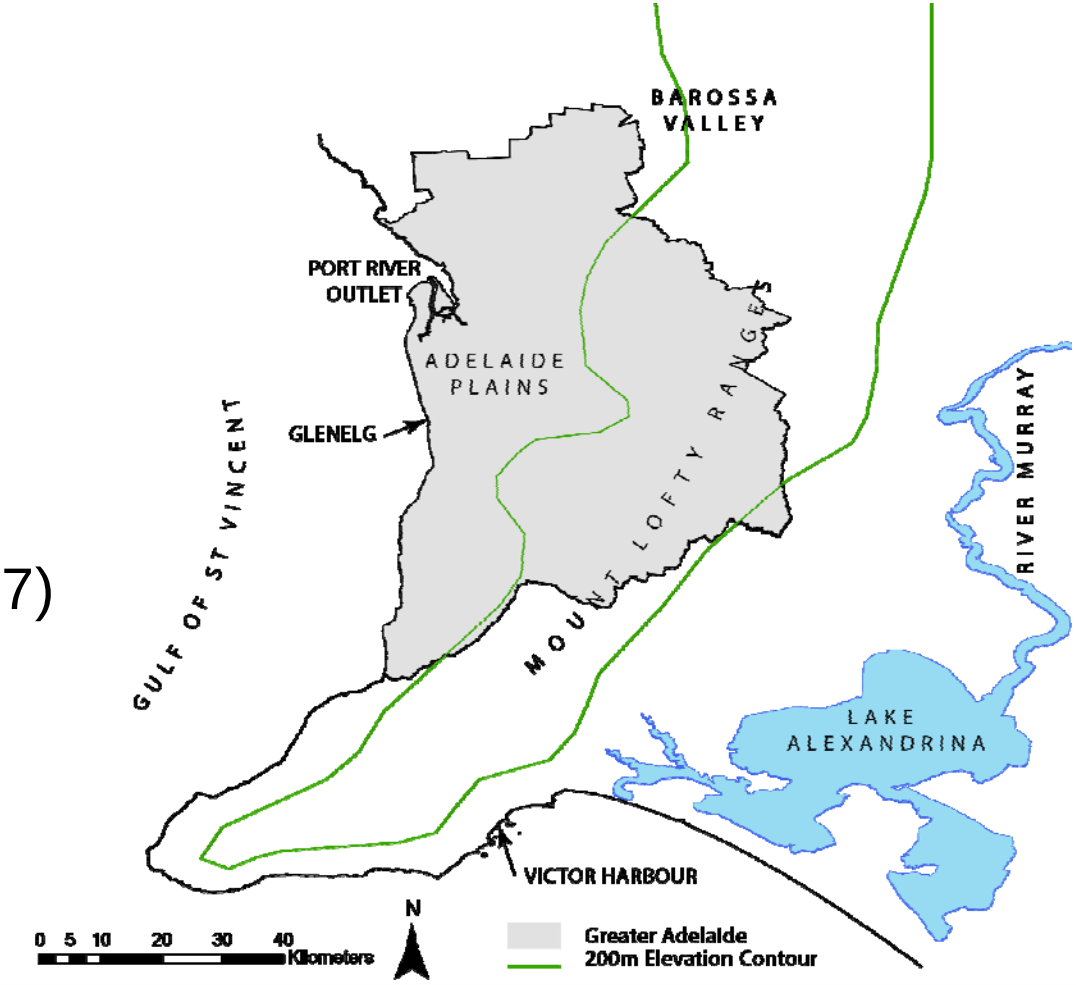
- Stakeholders:
  - Champion: Ed Pikusa (DEWNR)
  - Organisations: DCSI, SES (SA), DPC, SAFECOM, DPTI, DEWNR, OCIO, SAPOL, DECD, DPTI, SA Water, GA, SA Health, DTF, BOM, LGA, AG
- Status:
  - Four workshops
  - Completed scoping phase
  - Completed qualitative scenarios
  - Completed quantitative scenarios
  - Software development
    - Beta testing of the DSS software
    - Refinement/integration of hazard models
    - Integrating optimisation



CASE STUDIES

GREATER ADELAIDE: SCOPING

- Study region
  - Greater Adelaide
- Hazards
  - Bushfire
  - Earthquake
  - Coastal inundation
  - Flood
  - Heatwave
- Mitigation options (27)
  - Structural
  - Land use planning
  - Land management
- Indicators (31)
  - Economic, Social, Environmental

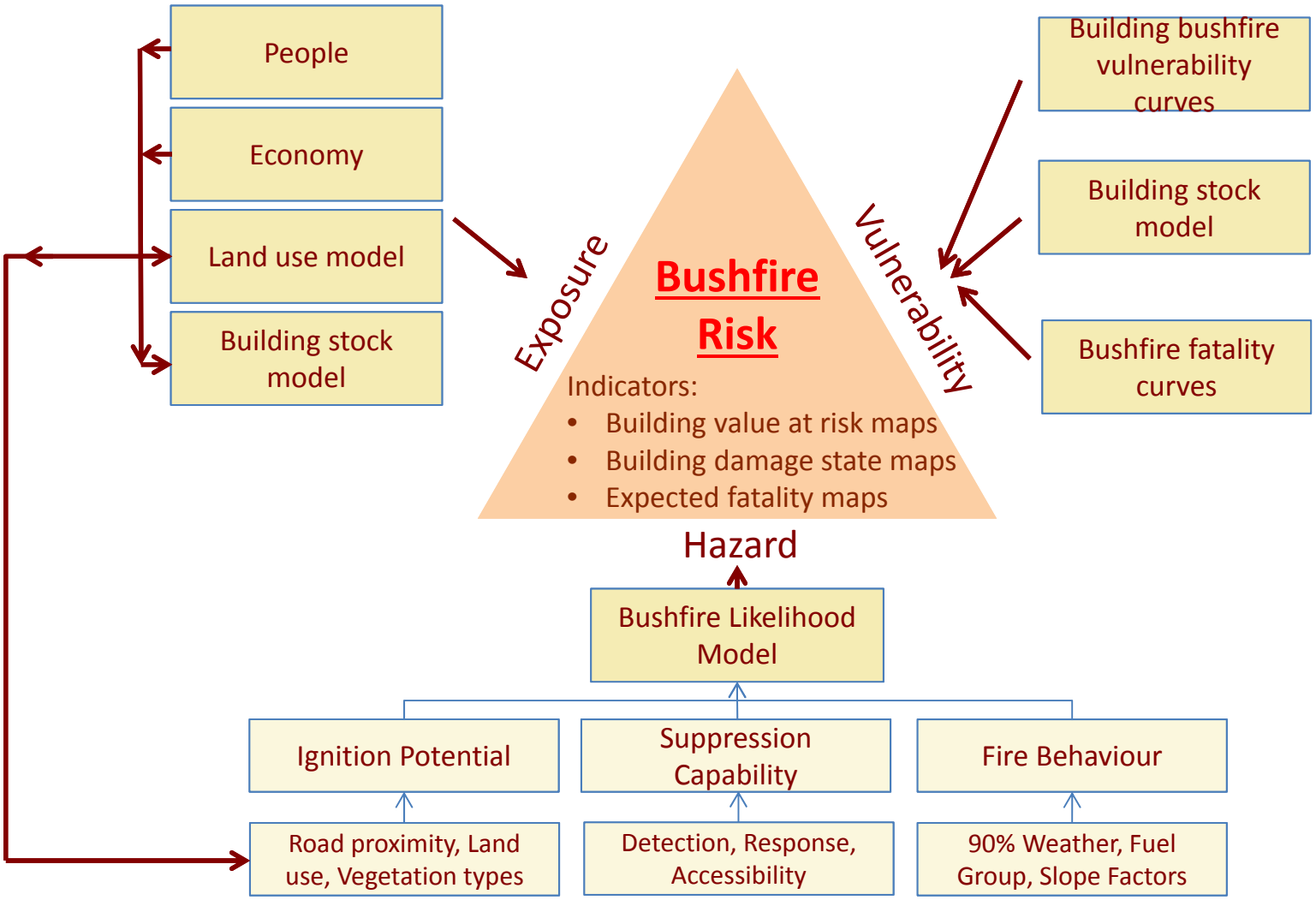


CASE STUDIES

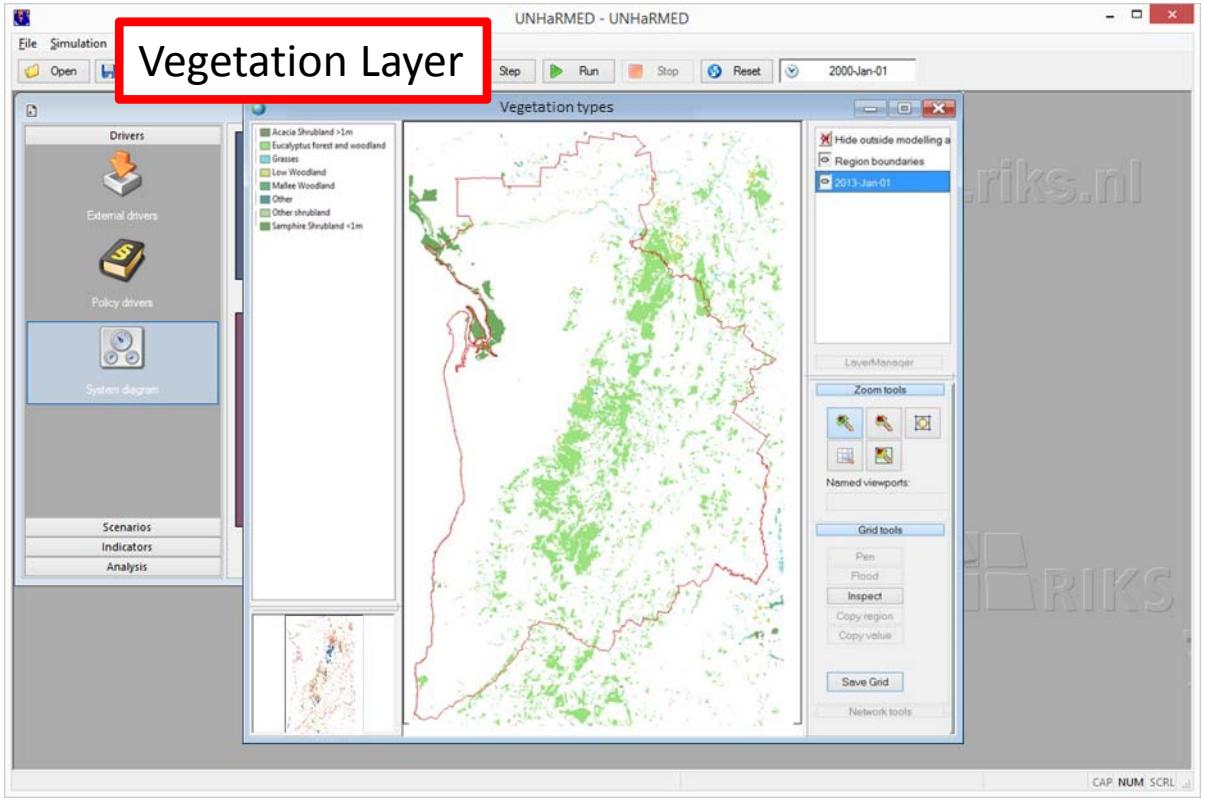
GREATER ADELAIDE: MODEL DEVELOPMENT

Hazard Models

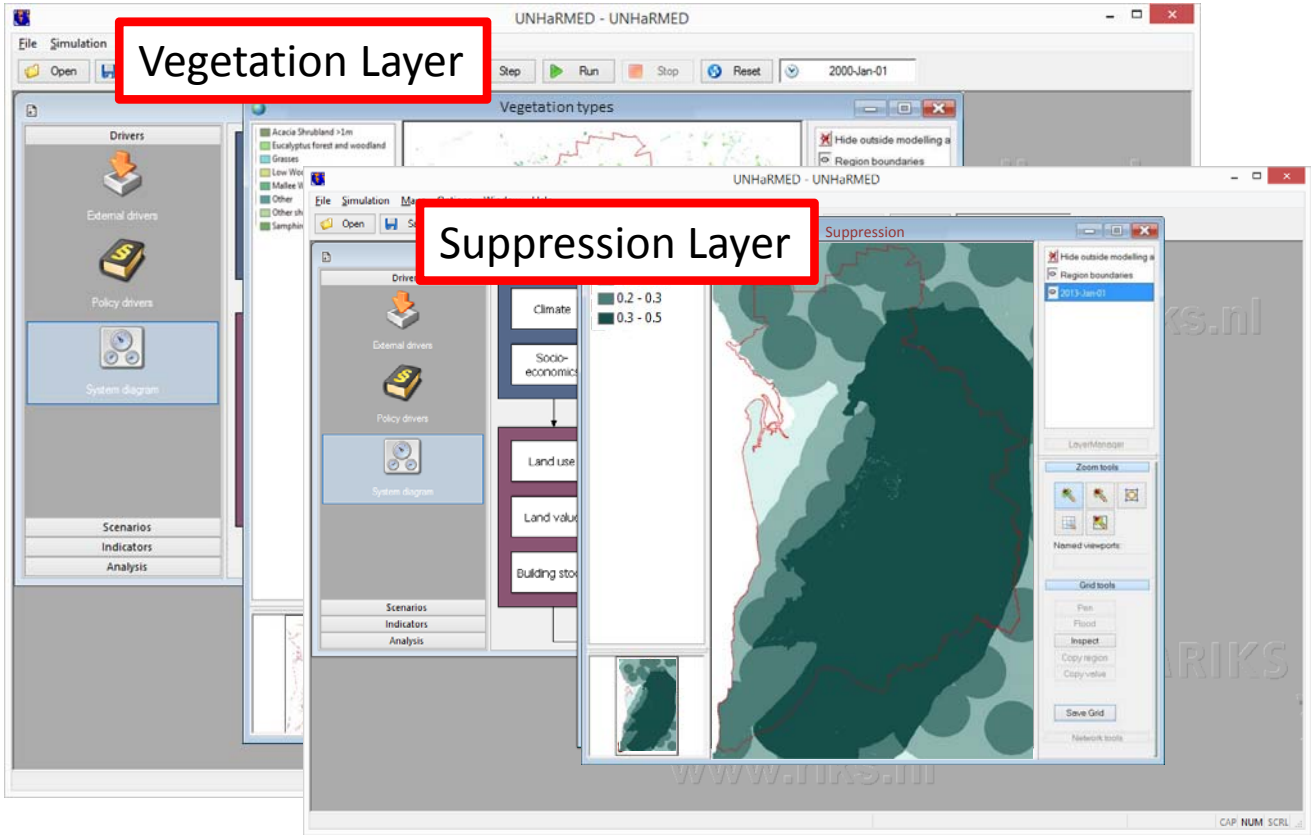
- Flooding
  - In-house zero-dimensional fluvial model
- Earth-quake
  - Probabilistic model consisting of 100 earthquake scenarios
  - Collaboration with Dr James Daniell Karlsruhe Institute of Technology, Germany)
- Coastal surge
  - In-house developed inundation model
- Bushfire model
  - Model based on BRAM (adapted from TASBRAM)
  - Collaboration with Mike Wouters and Simeon Telfer (DEWNR)
- Heatwave
  - In-house model developed based on excess heat factor
  - Consultation with John Nairne (BOM)


People
Economy
Land use model
Building stock model
Exposure
Bushfire Risk
Indicators:
• Building value at risk maps
• Building damage state maps
• Expected fatality maps
Vulnerability
Building bushfire vulnerability curves
Building stock model
Bushfire fatality curves
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

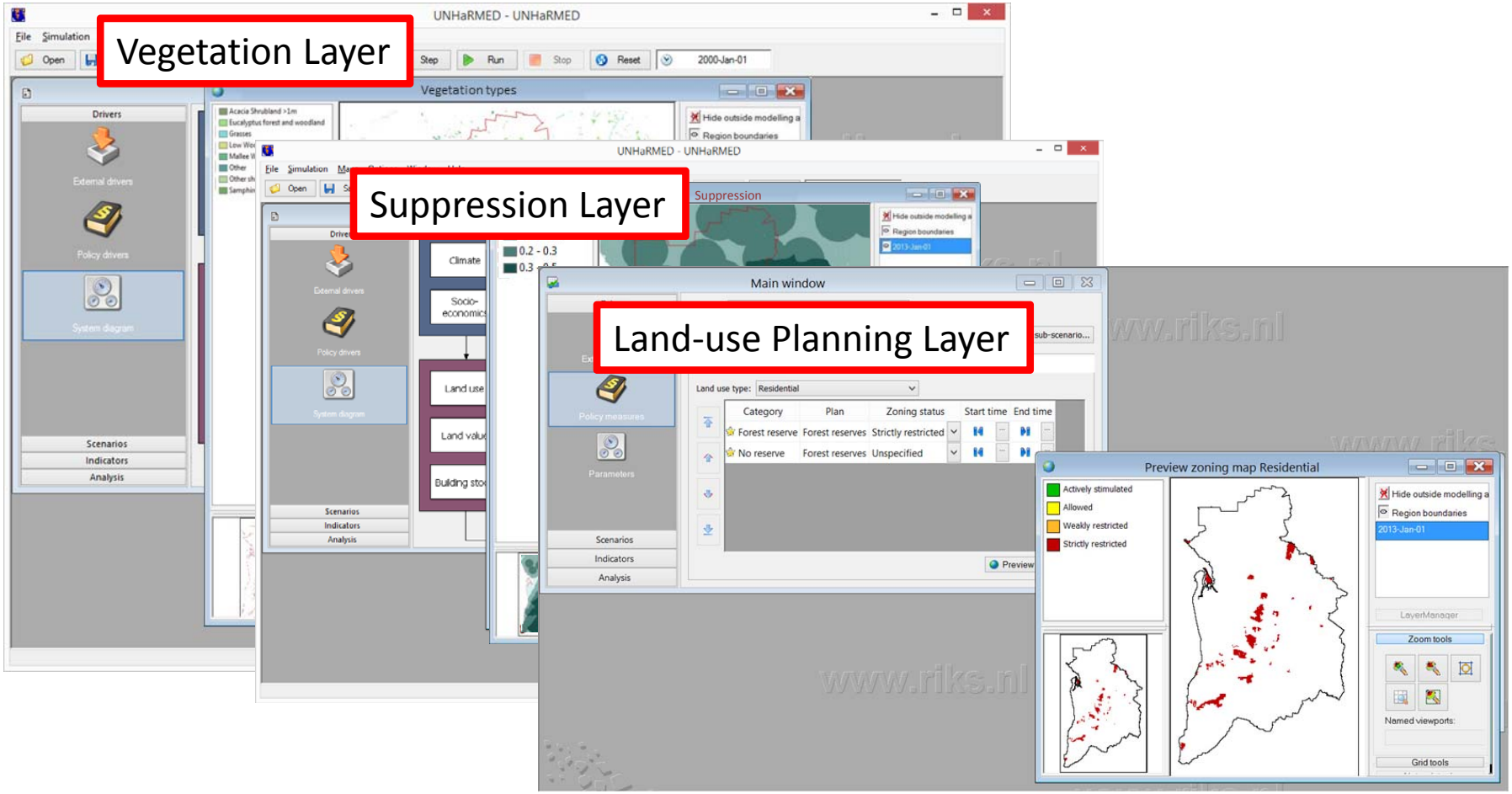
CASE STUDIES: *GREATER ADELAIDE*



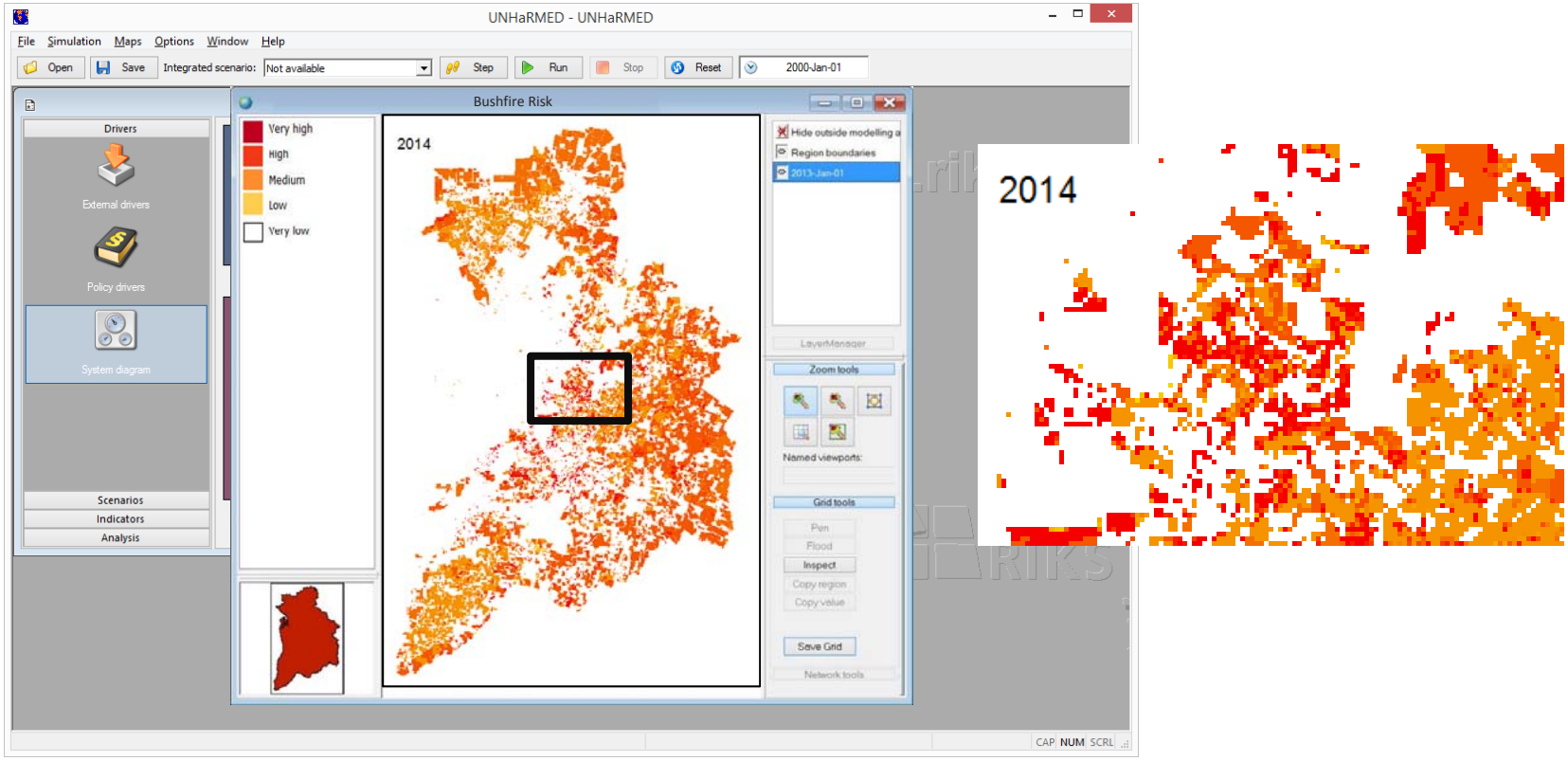
CASE STUDIES: *GREATER ADELAIDE*



CASE STUDIES: *GREATER ADELAIDE*



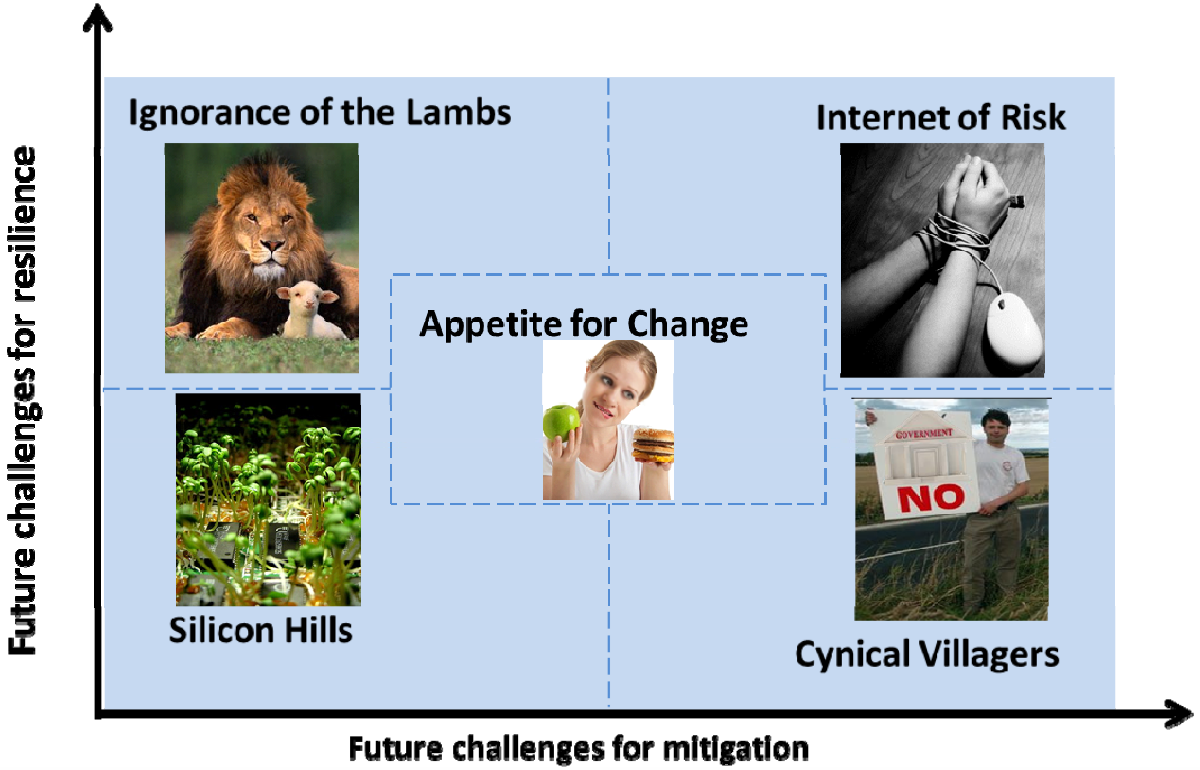
CASE STUDIES: *GREATER ADELAIDE*



CASE STUDIES

GREATER ADELAIDE: QUALITATIVE SCENARIOS

- Through the workshops, five scenarios were developed



CASE STUDIES

GREATER ADELAIDE: QUALITATIVE SCENARIOS

Ignorance of the Lambs

(High challenges to resilience)

- Decline in rural living
  - shift to highly urbanised centre
- High population growth with high immigration
  - Increased community vulnerability, heavy reliance on government for social and hazard-related support
- High mitigation cost means higher reliance on Federal Government
  - Loss of state-based policy, State Government as service provider
- Continued decline in manufacturing and high unemployment
  - Brain-drain to eastern sea-board, preferences for low cost housing

CASE STUDIES

GREATER ADELAIDE: QUALITATIVE SCENARIOS

Cynical Villagers

(High challenges to mitigation)

- Slowing population growth and immigration
  - Shifting in demographics to ageing population
  - Increases in rural residential developments
  - Increases in vulnerable communities
- Downturn in mining with no sector to replace activity
  - Strains on government revenue, and limited mitigation budget
  - Increases in low-middle income earners (urban sprawl and low cost housing)
- Local communities protective over their individual freedoms
  - High “local” knowledge, but limited “global” knowledge
  - Resistance to government policy and zoning regulations
  - High inequality in local understanding of risk

CASE STUDIES

GREATER ADELAIDE: QUANTITATIVE SCENARIOS

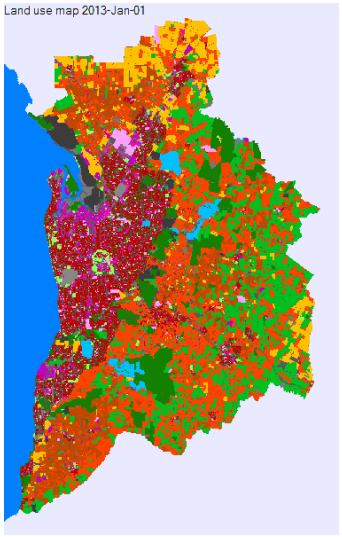
- Quantitative mapping of scenarios to model drivers

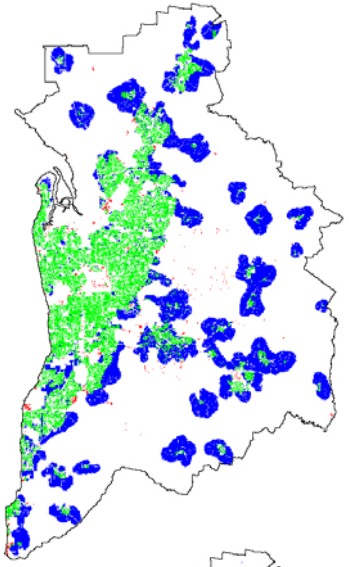
	Silicon Hills	Cynical Villagers	Ignorance of the Lambs	Appetite for Change	Internet of Risk
Population in 2050	1.9 M	1.5 M	2.5 M	1.8 M	1.5 M
Economy					
Community resilience					
Building stock resilience					
Residential land use developments	*Gradual growth urban and rural areas*	*Large increase in 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					

CASE STUDIES

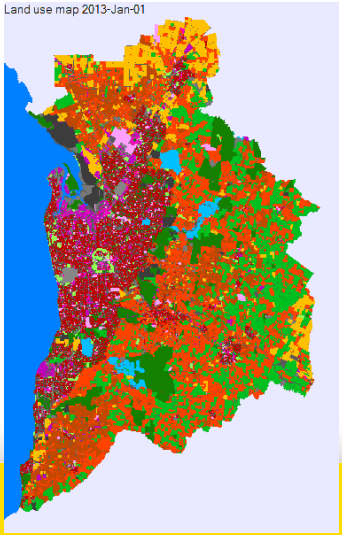
GREATER ADELAIDE: QUANTITATIVE SCENARIOS

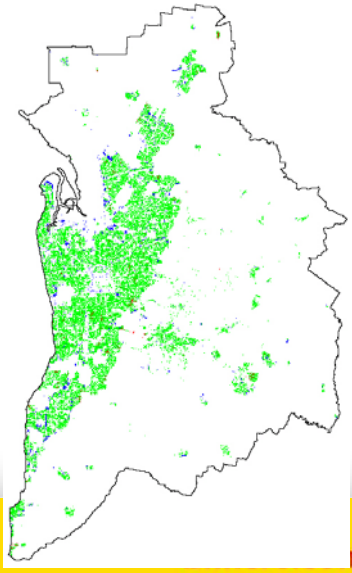
Ignorance of the Lambs





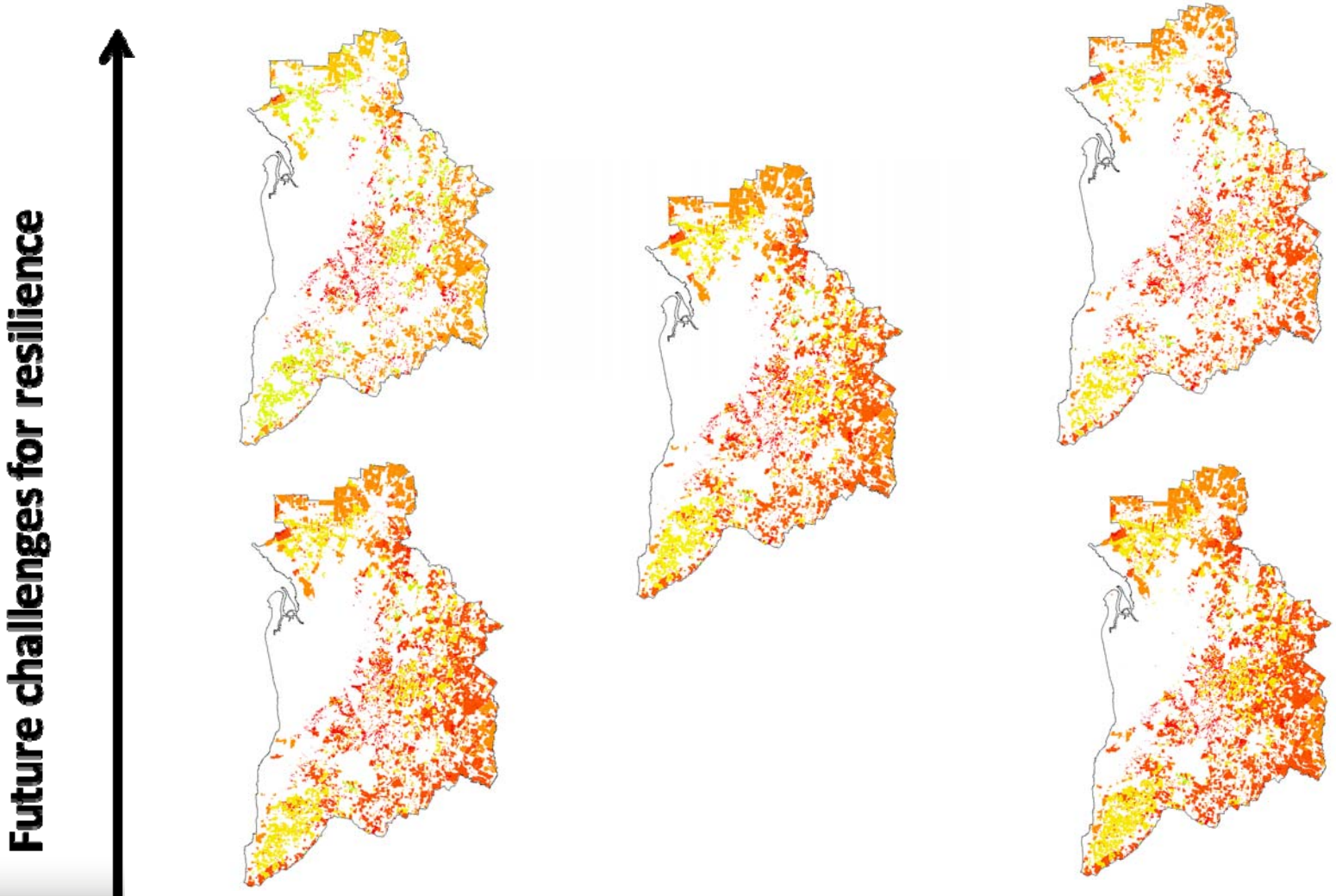
Cynical Villagers





DECISION SUPPORT SYSTEM FRAMEWORK

SOFTWARE FRAMEWORK



CASE STUDIES

GREATER ADELAIDE: NEXT STEPS…

- Finalise release version of DSS
  - Finalise and integrate hazards
  - Integration of optimisation
- Utilisation
  - Development of training manuals
  - Training of key stakeholders

CASE STUDIES

GREATER & PERI-URBAN MELBOURNE

- Stakeholders:
  - Champions: Alen Slijepcevic (CFA), Liam Fogarty (DELWP)
  - Organisations: CFA, DELWP, EMV, VU, VMIA, Melbourne Water, DEDJTR, DTF, DHHS
- Status
  - Three workshops
  - Completed scoping phase
  - Completed qualitative scenarios
  - Prototype under development
    - Developing, sourcing and integrating hazards models

CASE STUDIES

GREATER & PERI-URBAN MELBOURNE

- Study Region
  - Greater & Peri-Urban Melbourne
- Hazards (priority)
  - Bushfire
  - Riverine flooding
  - Storm
  - Heatwave
  - Earthquake
  - Sea level rise
- Mitigation options
  - Identified 24 key strategies
- Policy Indicators
  - Socio-economic (10); Environmental (8)

    Risk-based (10)

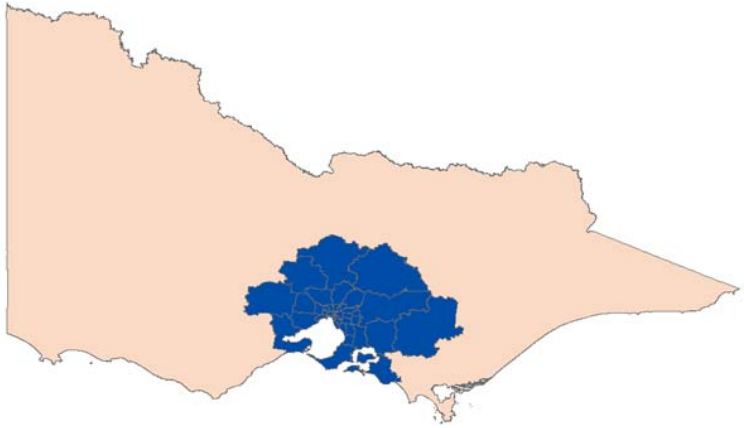


FIGURE 5: PROPOSED MODEL EXTENT

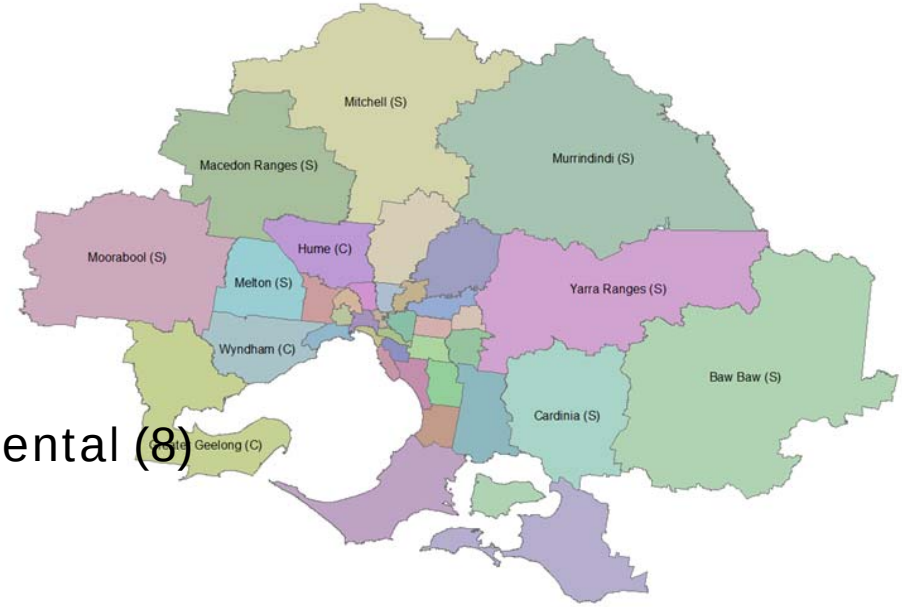


FIGURE 6: PROPOSED MODEL LGA EXTENT

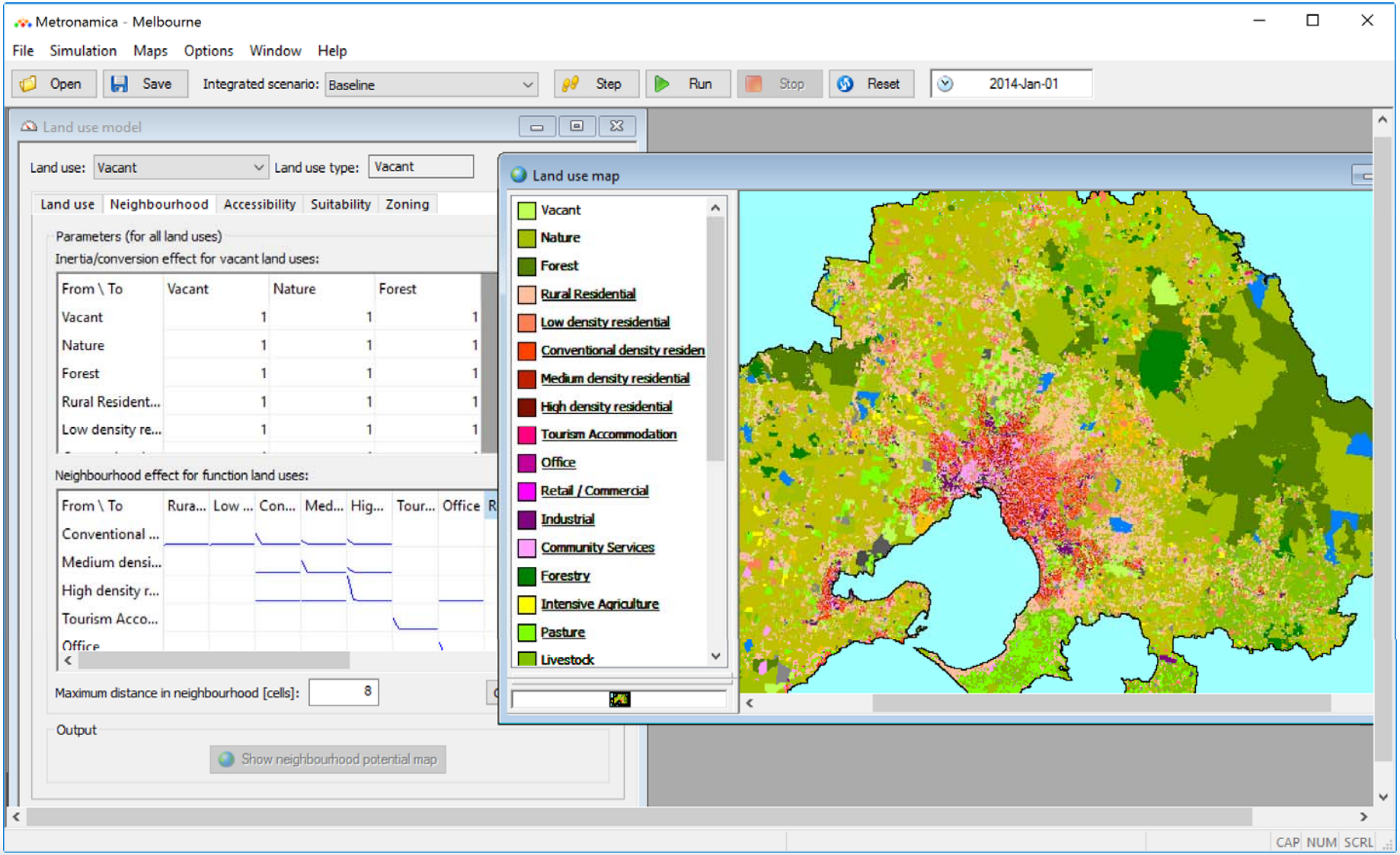
CASE STUDIES

GREATER & PERI-URBAN MELBOURNE

Hazard Models

- Coastal Surge
  - In-house developed inundation model
- Earthquake
  - Collaboration with Dr James Daniel Karlsruhe Institute of Technology, Germany)
- Bushfire
  - BRAMS based model
  - Incorporation of Phoenix modelling from DEWLP
    - Incorporation of fire path dependencies
    - Ember attack effects on Vulnerability
- Riverine Flooding
  - Utilisation of flood models from Melbourne Water

CASE STUDY: *G & P-U MELBOURNE*



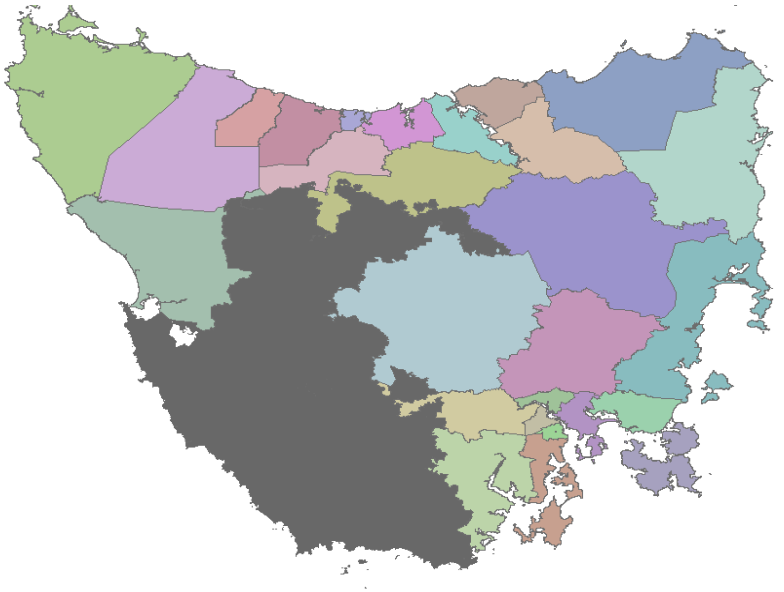
CASE STUDIES
TASMANIA

- Stakeholders:
  - Champion: Luke Roberts (DPaC-OSEM), Sandra Whight (TFS)
  - Organisations: DPaC (OSEM & CC), SES, TFS, Planning and Reform Taskforce, Kingborough Council
- Status
  - Two workshops
  - Completed scoping phase
  - Developed prototype land-use model

CASE STUDIES

TASMANIA: SCOPING

- Study Region
  - Entire Tasmanian Island
- Hazards (priority)
  - Bushfire
  - Coastal Surge
  - Riverine Flooding
  - Landslide
  - Earthquake
- Mitigation strategies
  - Identified 23 key strategies ranging from structural interventions to land-use planning and community-based
- Policy indicators
  - Social (7); Economic (10); Environmental (6); Risk-based (7)

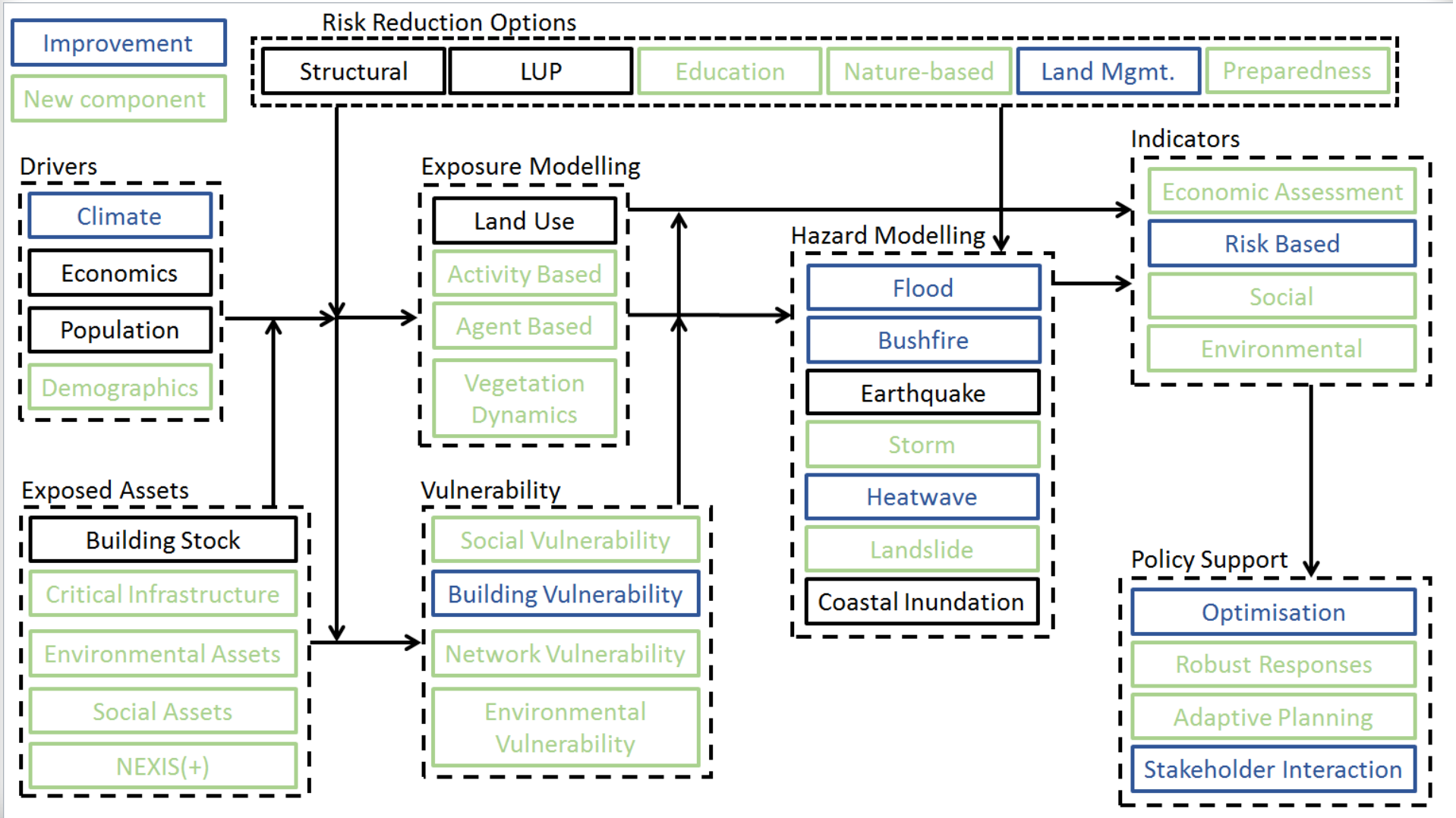


PROJECT PHASE 2

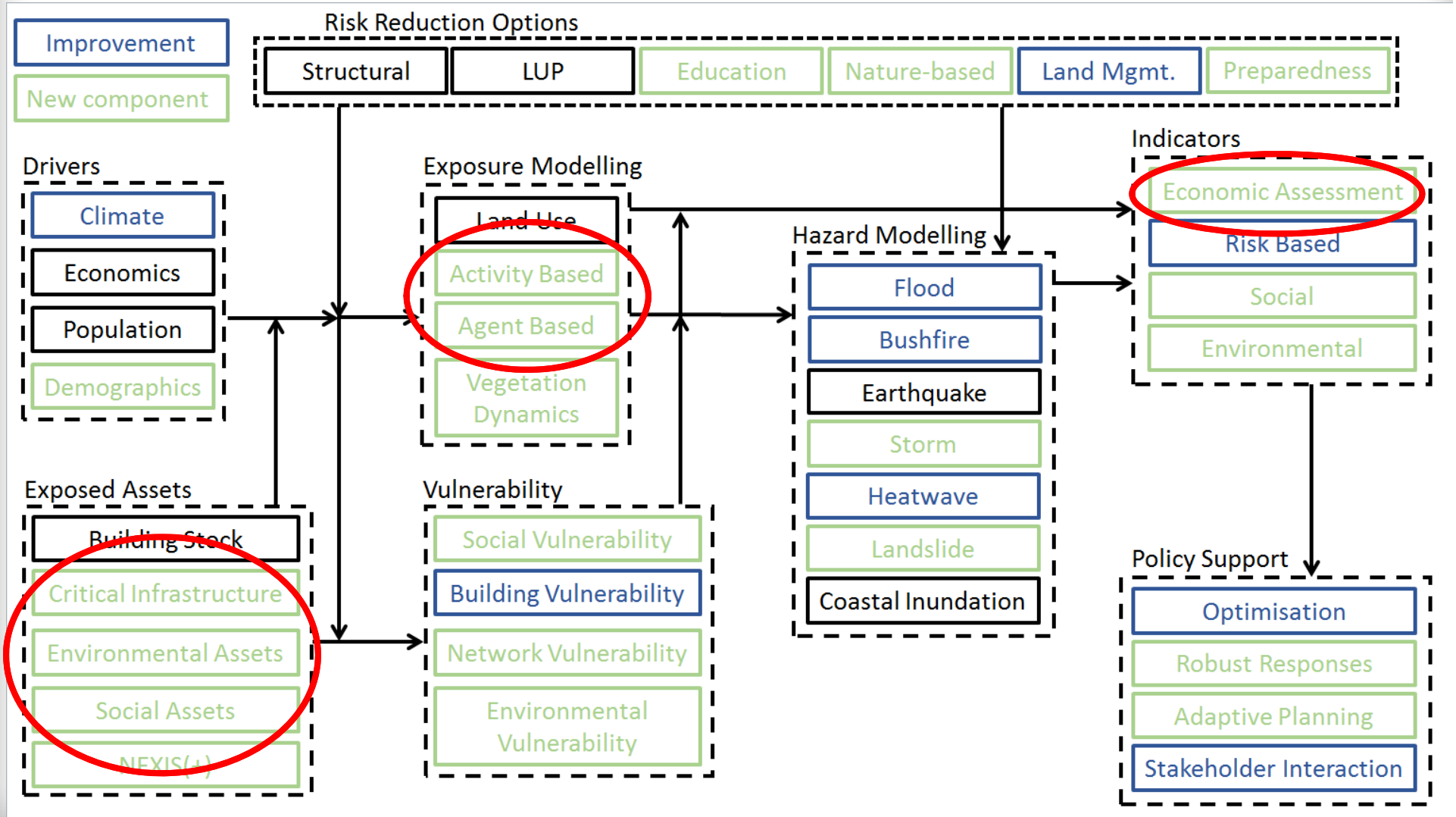
KEY TASKS

- Completion of Phase 1 DSSs and policy-support example
  - Greater Adelaide policy portfolio optimisation analysis
  - Completion of Greater Peri-Urban Melbourne DSS
  - Completion of Tasmania DSS
- Integration of DSS within end-user organisations
  - For Greater Adelaide:
    - Modification of DSS to allow for annual updating of vegetation layer
    - Provision of probabilistic land-use maps for use in flood impact modelling
  - Identification of utilisation pathways for GPUM and Tas DSSs
    - Policy-relevant simulations and reporting
    - Customisation of DSS for usability
    - Development of user manuals and training
- Enhancing DSS capability and functionality

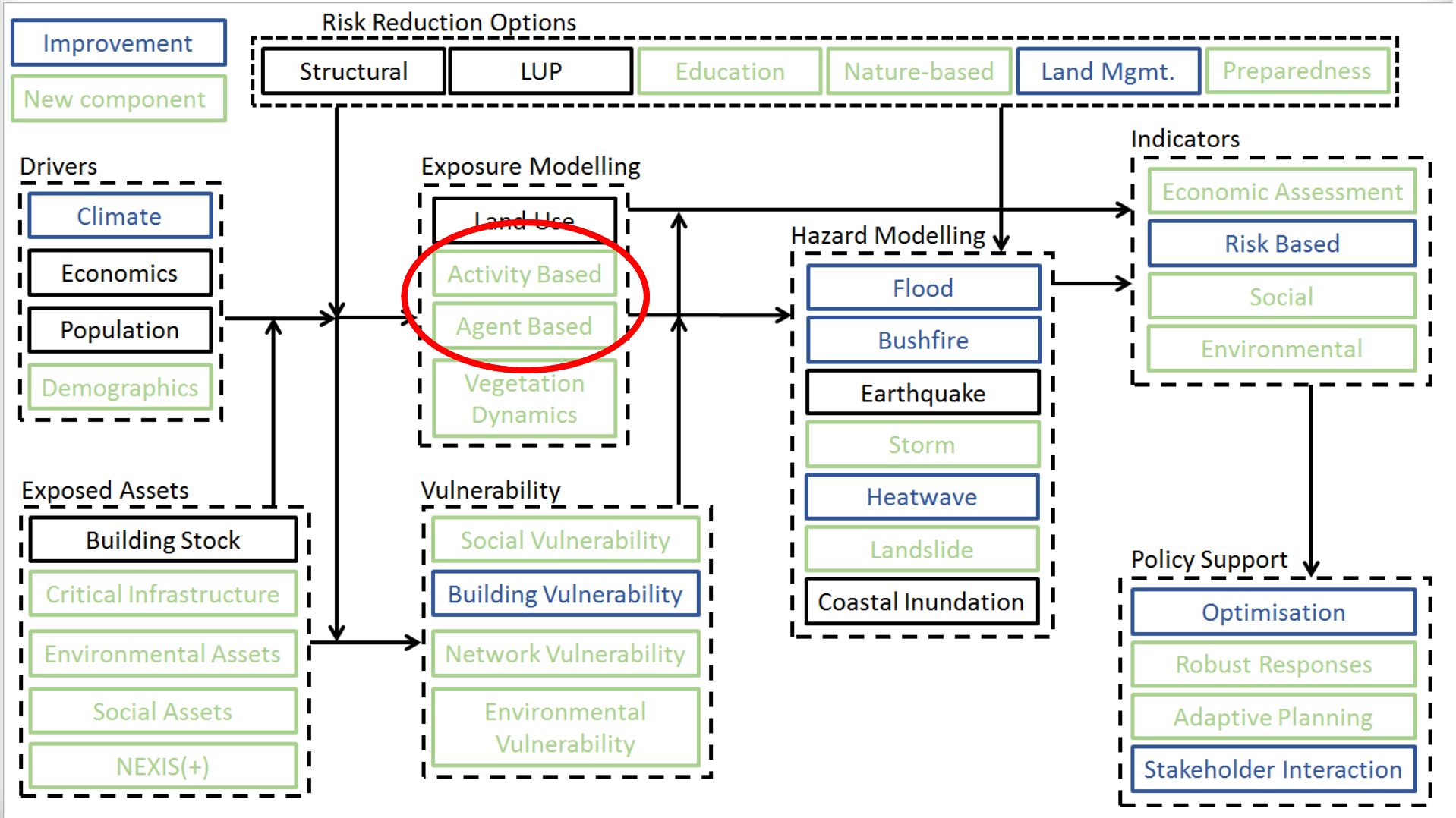
PROJECT PHASE 2: *ENHANCING DSS*



PROJECT PHASE 2: *ENHANCING DSS*



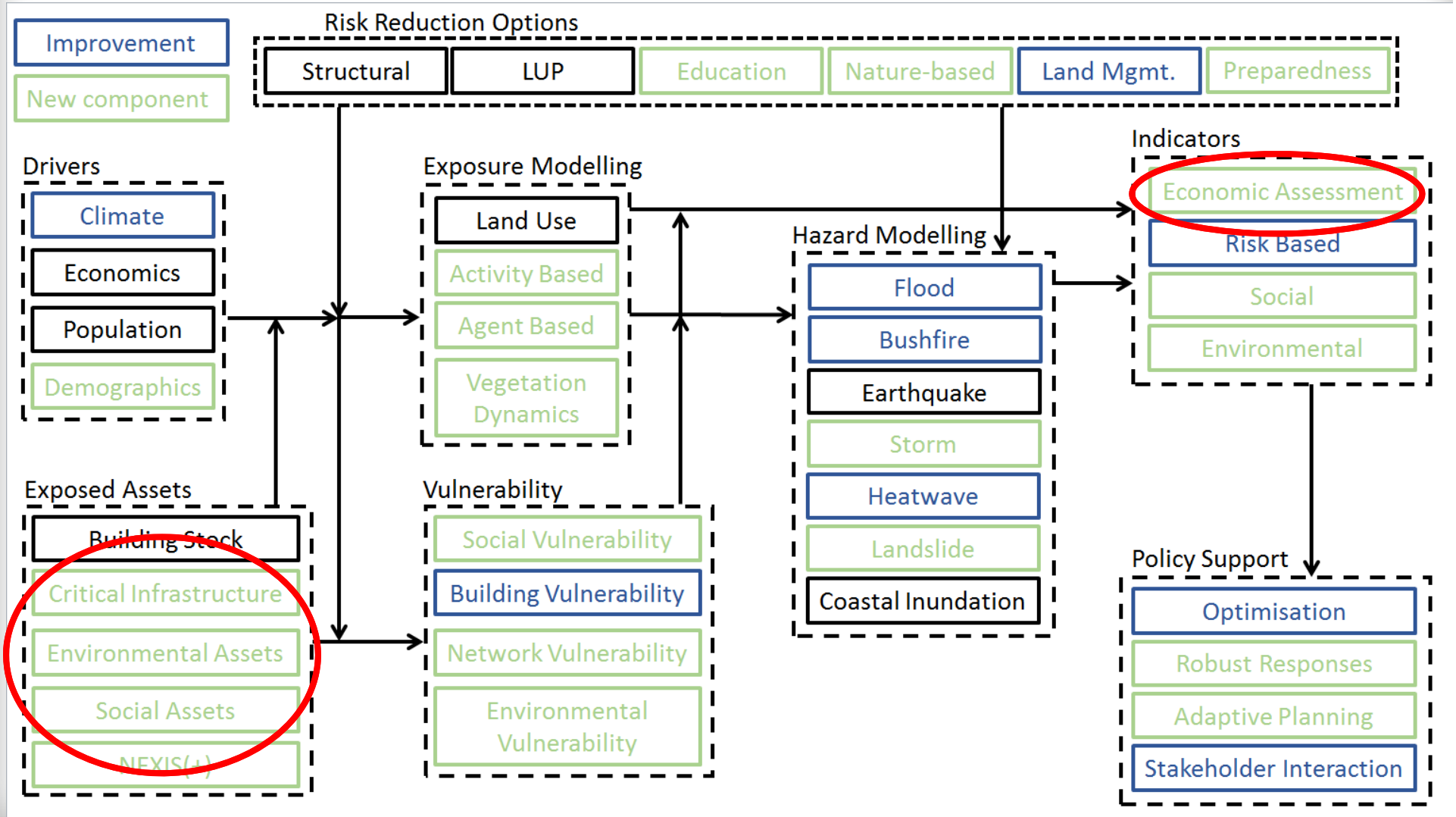
PROJECT PHASE 2: *ENHANCING DSS*



PROJECT PHASE 2
ENHANCING DSS

- Activity Based Model
  - Incorporation of demographic information for disaggregation of societal groups
  - Aim is to better capture the differing vulnerability of different social group
    - (e.g. elderly, young families, migrant groups)
  - Applied to Greater and Peri-Urban Melbourne case study
- Agent Based Modelling
  - Improved characterisation of social aspects of bushfire risk
    - Influence of past hazard experience, duration in an urban or rural environment and education on social vulnerability
  - Applied to Greater Adelaide case study

PROJECT PHASE 2: *ENHANCING DSS*



PROJECT PHASE 2
ENHANCING DSS

- Inclusion of indirect and intangible economic factors
  - Improved characterisation of benefit:cost
    - Cost of “flow on” impacts (disruption, productivity, etc)
    - Valuation of amenity
  - Link with Project A6 “Economics of bushfires and natural hazards”
- Improved characterisation of exposed assets
  - Include critical assets beyond building stock
    - Cultural, economic, and environmental assets
  - Apply to the Greater Peri-Urban Melbourne DSS

FUTURE OPPORTUNITIES

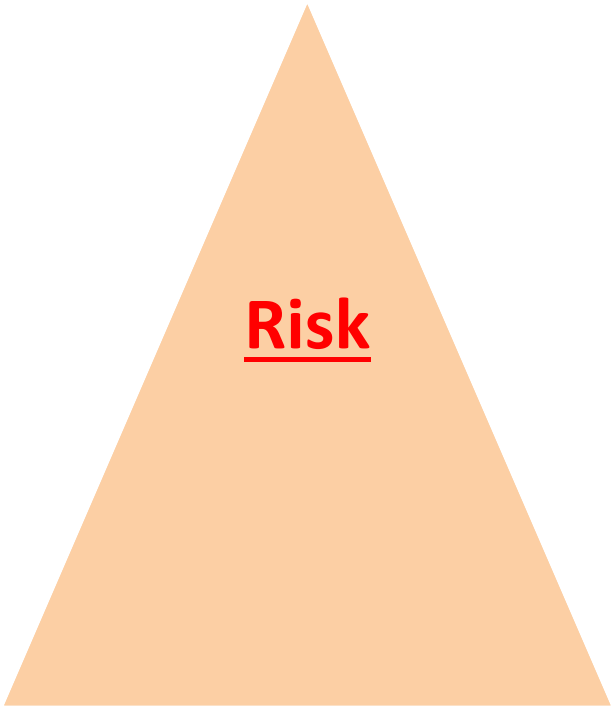
- Project proposals for NDRP funding
  - Western Australian case-study
  - Extended South Australian case-study
- In discussions for a Queensland case-study
- Extensions for Greater and Peri-Urban Melbourne
  - Use of scenarios for community engagement (with CFA)
  - Integration of DSS with urban planning (transport models, and “resilient Melbourne”) (with DEWLP)

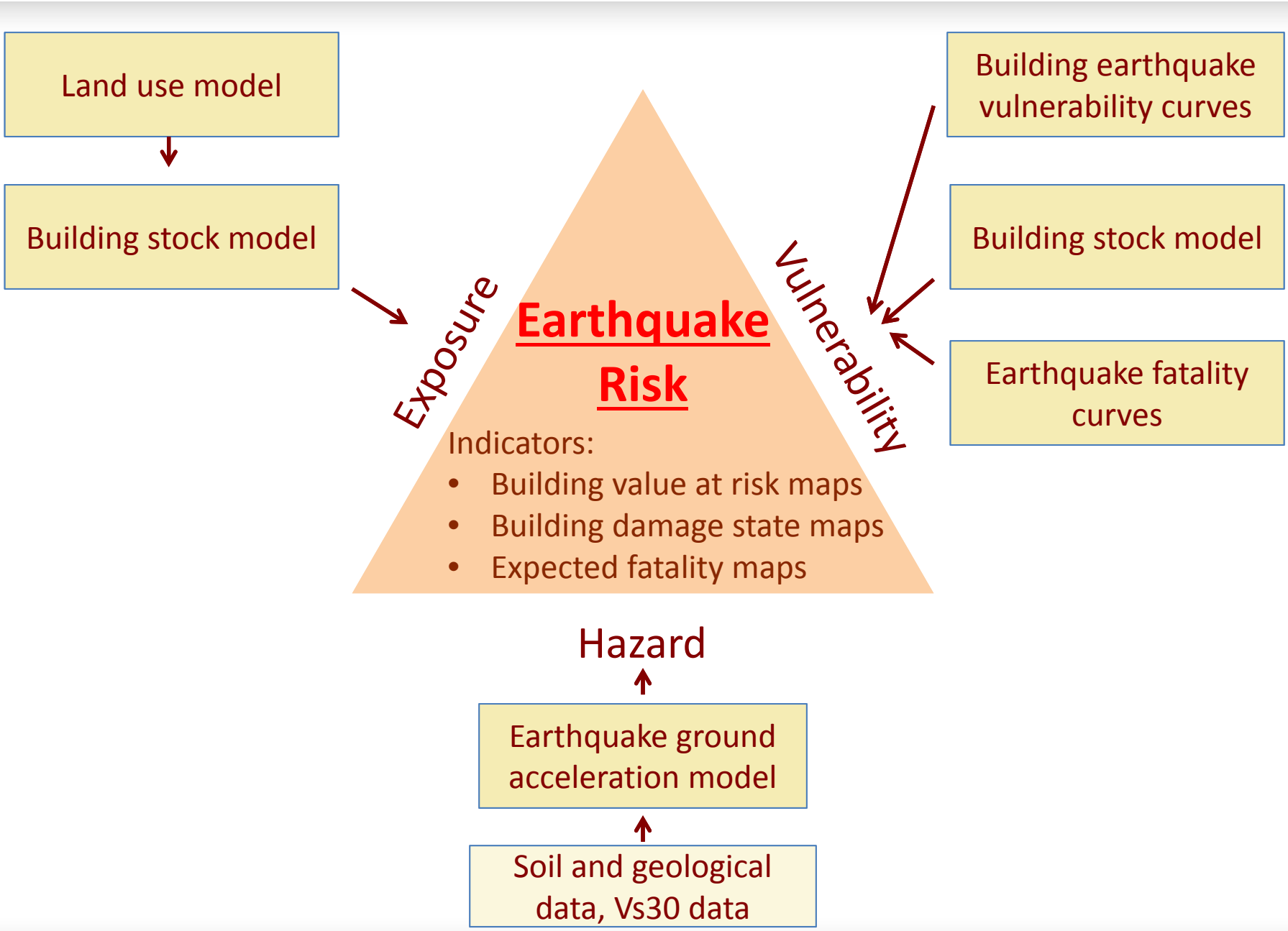
THANKS FOR YOUR ATTENTION!

ADDITIONAL SLIDES

DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

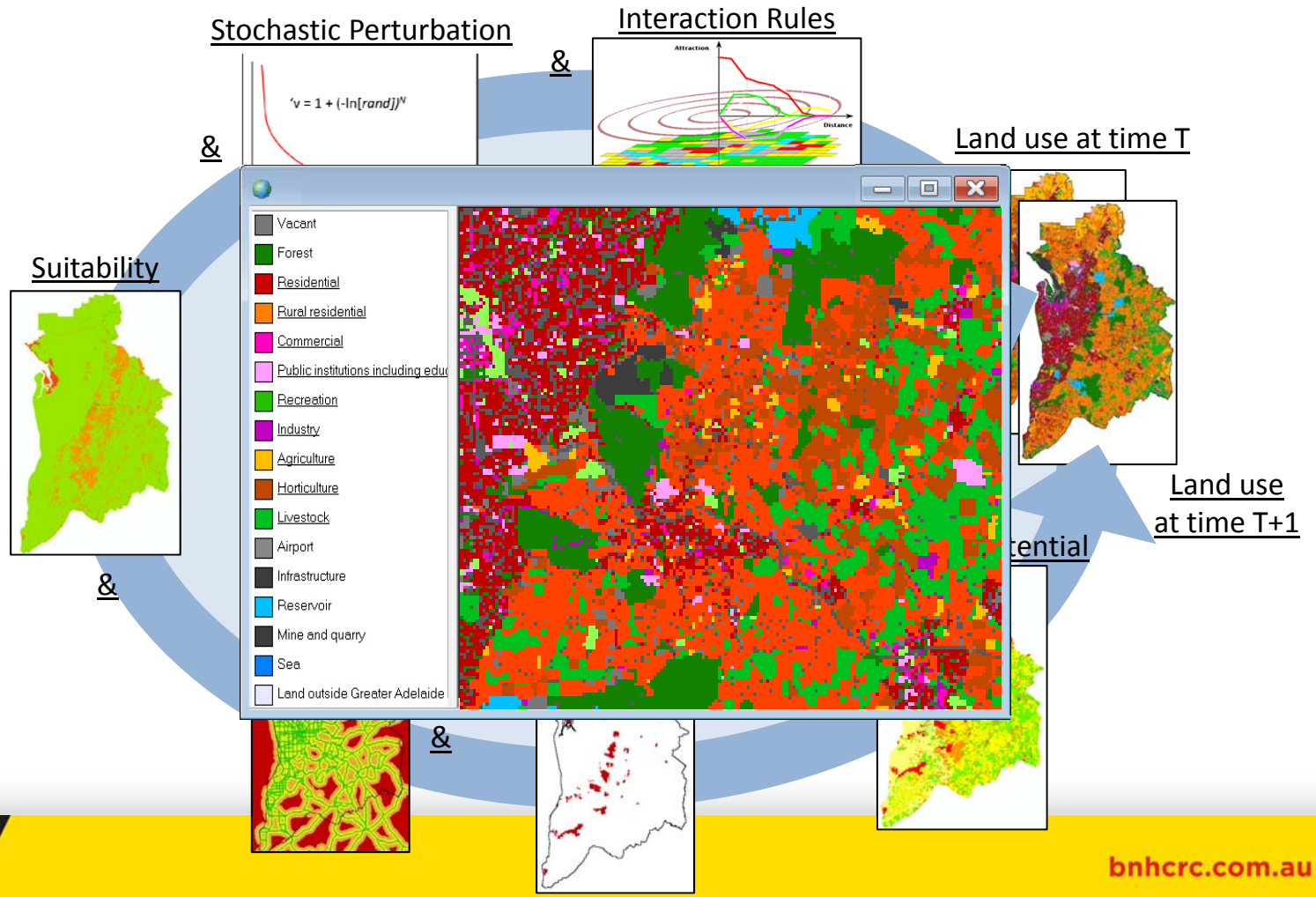



Land use model
Building stock model
Exposure
Earthquake Risk
Indicators:
• Building value at risk maps
• Building damage state maps
• Expected fatality maps
Vulnerability
Building earthquake vulnerability curves
Building stock model
Earthquake fatality curves
Hazard
Earthquake ground acceleration model
Soil and geological data, Vs30 data

DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

Exposure Model



*"Land use planning is perhaps **the most potent policy lever** for influencing the level of future natural disaster risk"*

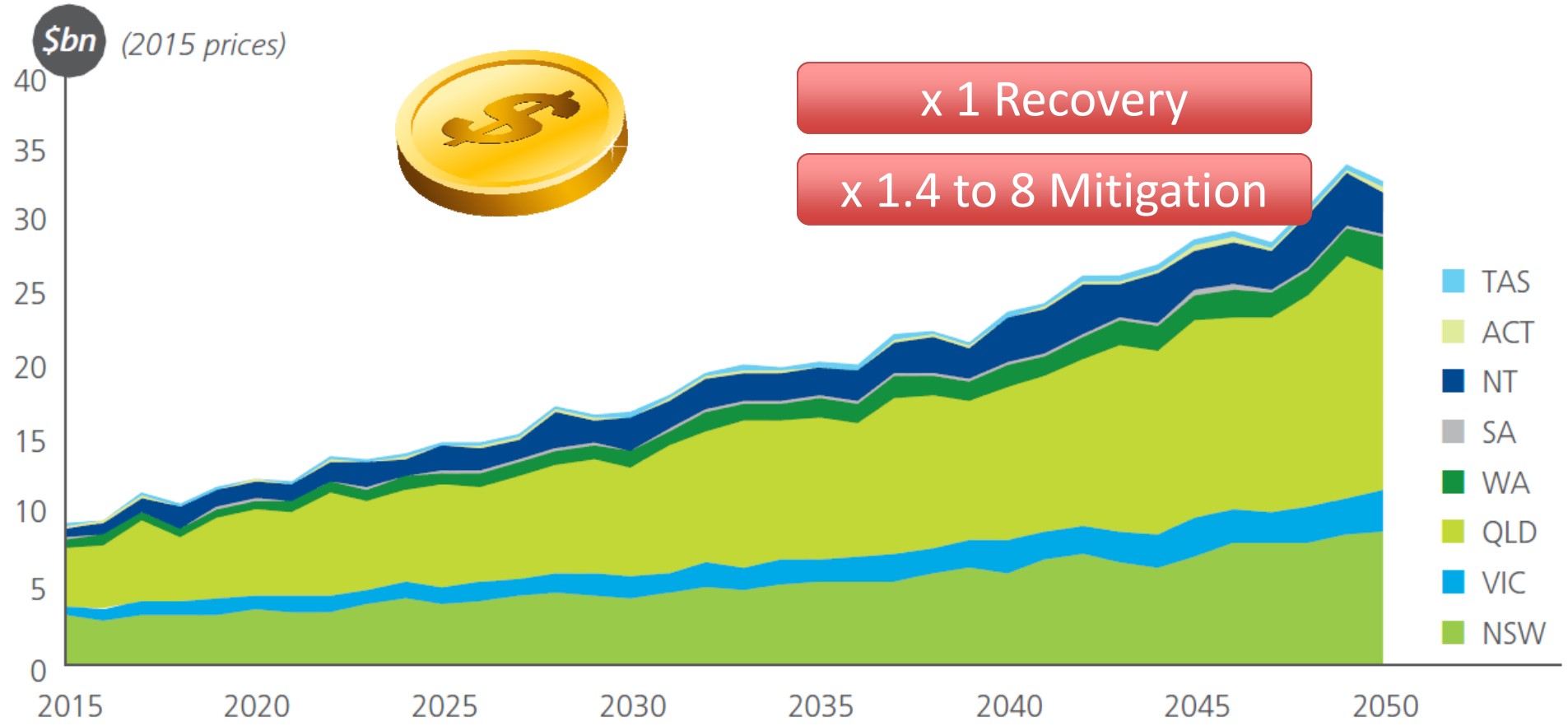
PREVENTION IS BETTER THAN CURE

COST

BENEFIT

x 1 Recovery

x 1.4 to 8 Mitigation

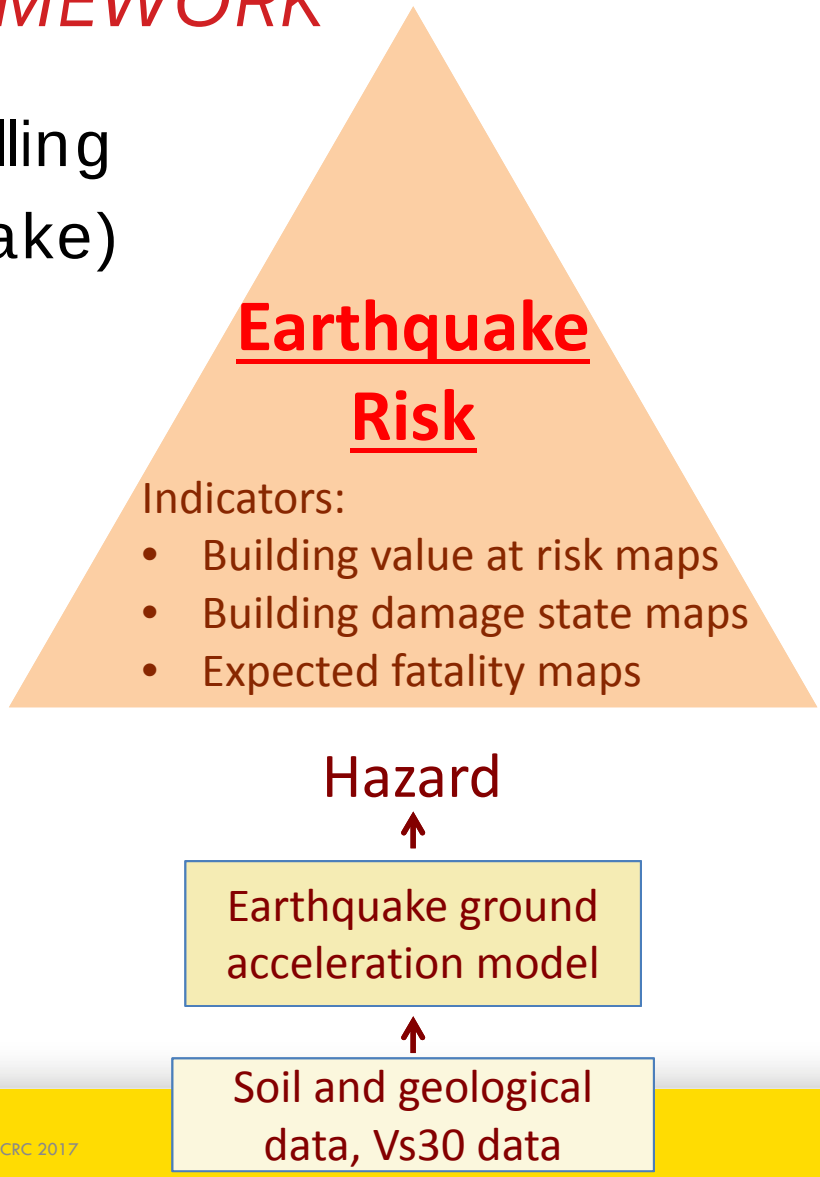


Source: Deloitte Access Economics analysis

DECISION SUPPORT SYSTEM FRAMEWORK

MODEL FRAMEWORK

Hazard Modelling
(e.g. earthquake)



AZ9

CASE STUDIES
APPROACH

- Phase 1 – Scoping
  - Build understanding of current Landscape of natural hazard management
    - Key Hazards; Key factors effecting mitigation; Key drivers of change; Major uncertainties
  - Identification of mitigation options
  - Indicators and Factors of Risk
  - Region and Extent of DSS
  - Implementation of DSS
- Phase 2 – Qualitative scenario development
- Phase 3 – Quantitative scenario development
- Phase 4 – Development of optimisation

AZ9 modify/refine

Aaron Zecchin, 31/03/2017

LAND MANAGEMENT	Planned burning, reduction of fuel load	Improved enforcement mechanisms (e.g. illegal veg clearance)	Land reclamations
COMMUNITY BASED	Arson reductions programs	Integration of hazard programs in school curriculum	Increase community awareness (risks, safety strategies)
STRUCTURAL	Building Hardening (in particular for residential infrastructure)	Providing more assistance to owners of buildings in hazard areas to upgrade buildings	Structural upgrade of legacy buildings not currently code compliant
LEARNING (RESPONSE TO PP)	Agreement on residual risk, government and communities	Implementation of business continuity plans	Structured framework for lessons learnt
INSTITUTIONAL CHANGE	Establishment of multi hazard agencies	Tougher legislative requirements to build in higher risk zones	Adaptive policies (thresholds) for decision making (linking with adaption to climate change)
LAND USE PLANNING	Building exclusion areas, flood plains, bushfire areas	Ensuring development in hazard prone areas are compliant to highest codes	Increase access to information for property owners
LEGISLATION	Regulatory requirements to consider natural hazard risk in planning	Provide Hazard Leaders/control agencies with greater powers to question developments	Resource planning to mitigate response/recovery

MODELLER INTERFACE LAND USE