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

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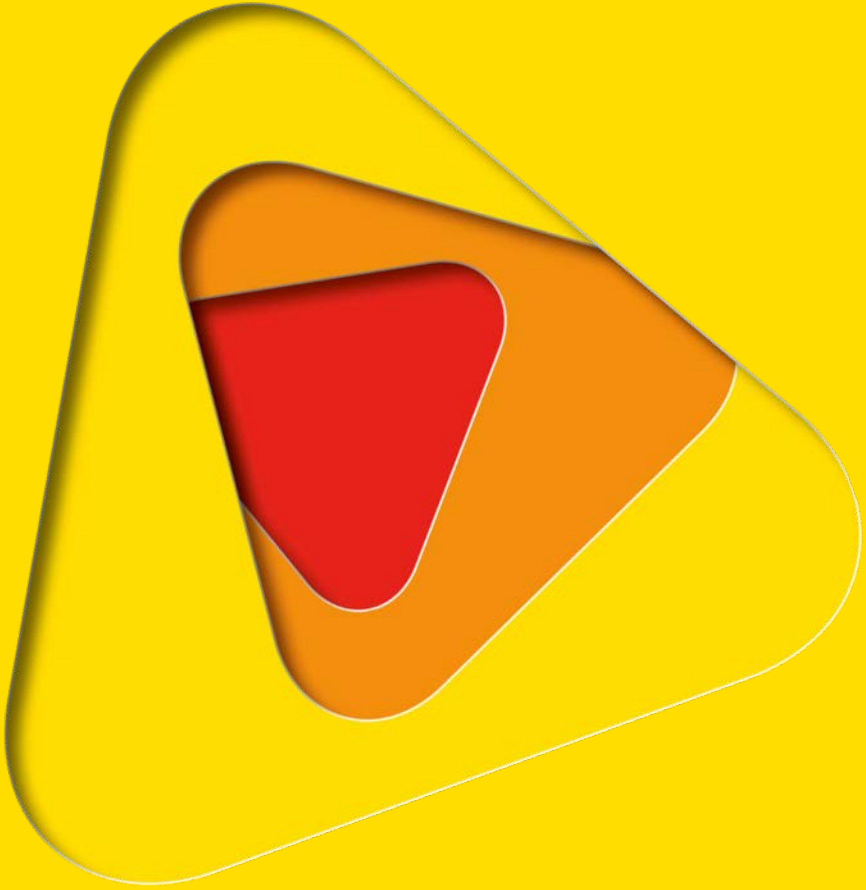

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EXTENDED ABSTRACT

The challenges facing environmental policymakers grow increasingly complex and uncertain as more factors that impact on their ability to manage the environment and its risks need to be considered. Due to a large number of influencing environmental and anthropogenic factors, natural hazard risk is difficult to estimate accurately, and exaggerated by large uncertainty in future socioeconomic consequences. Furthermore, resources are scarce, and the benefits of risk reduction strategies are often intangible. Consequently, a decision support system assisting managers to understand disaster risk has great advantage for strategic policy assessment and development, and is the focus of this extended abstract.

The spatial decision support system (SDSS) presented is being developed in collaboration with several South Australian government departments and funded by the Bushfire and Natural Hazards CRC. It integrates multiple hazard models with a land use model which includes information on population and building stock to consider long term spatial and temporal dynamics of natural hazard risk. The integrated SDSS operates at a 100m resolution with a time-step of one year and can be used to model 20–50 years into the future. Hazards included in the SDSS include riverine flood, coastal inundation, bushfire, heatwave and earthquake. Each is modelled dependent on the relevant physical properties of the hazard and include the impacts of climate change on hydro-meteorological, bushfire and heatwave hazard. The land use model is driven by land use demand (population and jobs), and allocates land accordingly.

The SDSS conceptualises and subsequently models risk as the combination of the natural hazard, exposure and vulnerability (UNISDR, 2009). The modelling of risk across these three factors, simulating their spatial and temporal dynamics, improves understanding of long-term risk. It also allows for consideration of risk reduction options to be implemented across each of the factors targeting specific aspects of the risk. Figure 1 highlights the overall architecture of the system, showing external drivers influencing exposure and hazard dynamics (socioeconomics and climate), along with risk reductions options on different components of risk, and a series of indicators calculating risk in terms of average annual loss, and the economic effectiveness of risk reduction options.

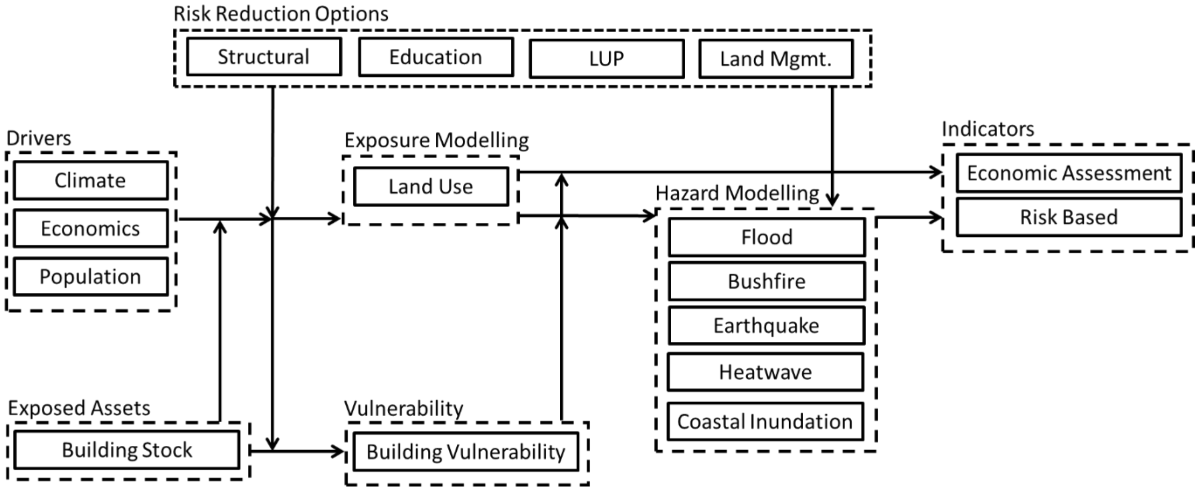


FIGURE 1. OVERALL ARCHITECTURE OF PROPOSED SPATIAL DECISION SUPPORT SYSTEM

Within the SDSS, exposure is considered dynamically with the inclusion of a land use allocation model (RIKS, 2015) and building stock information retrieved from the NEXIS database (Dunford et al., 2015). The land use allocation model operates on a square grid of 100m cells. The model is cellular automaton (CA) based and calculates the state of each cell within the overall growth of the region of interest (Greater Adelaide for this study), driven by population and economic demands (White and Engelen, 1993). The CA model stochastically allocates the land use demands at an annual time step based on the land uses at the previous time step and the spatially dependent, attractive and repulsive forces that land uses exert on each other within a close neighbourhood. There are three additional site specific factors that influence the potential for a land use to change, namely suitability, zoning status and accessibility (van Delden et al., 2007).

Suitability relates to the physical aptness of a cell to support a particular land use and its activities. Examples of this include soil type or slope. Suitability is represented as one map per land use function modelled. Zoning, similarly represented as one map per land use function, specifies when a cell can or cannot be changed to a particular land use for various planning periods and how strict or flexible the policy is. Accessibility expresses the ease with which the activities associated with each land use can fulfil their requirements for transportation, mobility or any other infrastructure need based on each cell's proximity to networks (van Delden and Hurkens, 2011).

A suite of hazard models is also included, as shown in Figure 1. For bushfire, coastal inundation, riverine flood and earthquake, average annual direct loss is calculated using appropriate processes and input data to capture the nature of the hazard. For example, bushfire hazard likelihood and intensity is considered using three factors; ignition potential (a function of land use, road proximity and vegetation), suppression capability (the probability of first wave attack success), and fire behaviour (a function of climate, slope and fuel load). Hydro-meteorological hazards are considered using a digital elevation model and inundation depths for various return periods and future climate scenarios. Earthquake hazard is calculated by a using a probabilistic set of a 100 events calibrated on historical earthquake events in the region. For each of these hazards direct losses are considered by taking the magnitude outputted from the hazard models and converted using vulnerability curves for the building stock dependent on its construction type. By using these curves, for specific hazards and construction types, relative damage indices can be multiplied by the building stock's value providing an output of direct monetary loss. Heatwave hazard is considered in terms of increased mortality. This is achieved by calculating the number of excess deaths, using relationships between percentage of excess deaths and excess heat factor, as well as population and mortality rate projections, for climate-affected time series of daily temperatures at a number of locations, which are then spatially interpolated.

Risk reduction options are also considered across hazard, exposure and vulnerability. For hydro-meteorological hazards, structural measures such as levies and sea walls can be implemented to alter flow and inundation paths, whereas vegetation management (planned burns) can be used to influence fuel loads in the calculation of bushfire intensity. Spatial planning measures can also be implemented, reducing exposure to all hazards. In addition, changes to building codes and retrofitting can be considered by altering the vulnerability curves that relate hazard magnitude to damage.

Along with the technical development of the modelling platform is an integrated and participatory development and use process. This process brings together the knowledge of scientists, IT specialists, and end users to develop a problem-specific model platform, along with modellers, facilitators and stakeholders, to explore the application of the platform to a problem of interest, exploring policy options, indicators and future scenarios. Figure 3 highlights the iterative loop between the development and use cycles.

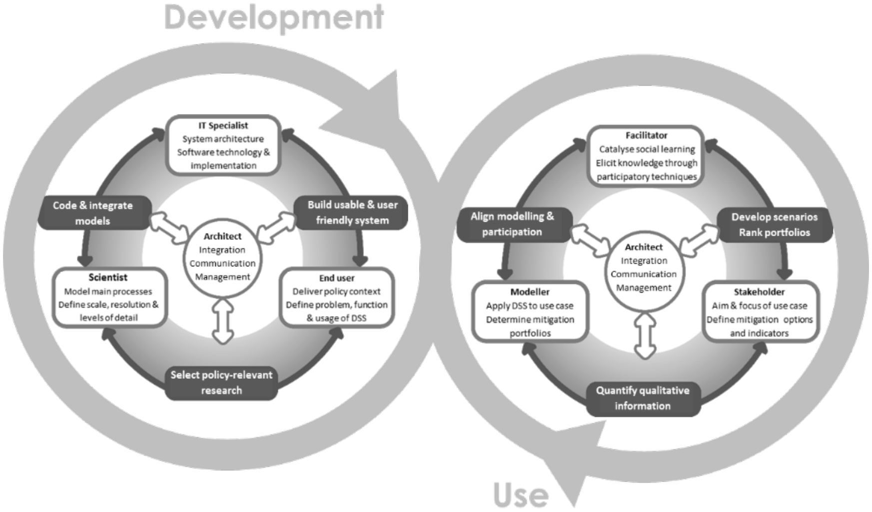


FIGURE 2. DEVELOPMENT AND USE CYCLE

This development and use process has been applied to Greater Adelaide, developing the modelling platform through end user engagement with the State Mitigation Advisory Group (SMAG) and applying it to consider future risk profiles. Five scenarios were developed considering the future of Greater Adelaide. These scenarios were developed by initially considering the risk reduction options at the avail of decision makers, grouped into resilience or mitigation focused options. These foci were used as framing axis for the scenarios, shown in Figure 4. The two foci were further discussed considering the factors that contributed to their success or failure, and these factors were then used as the building blocks of the scenario storylines.

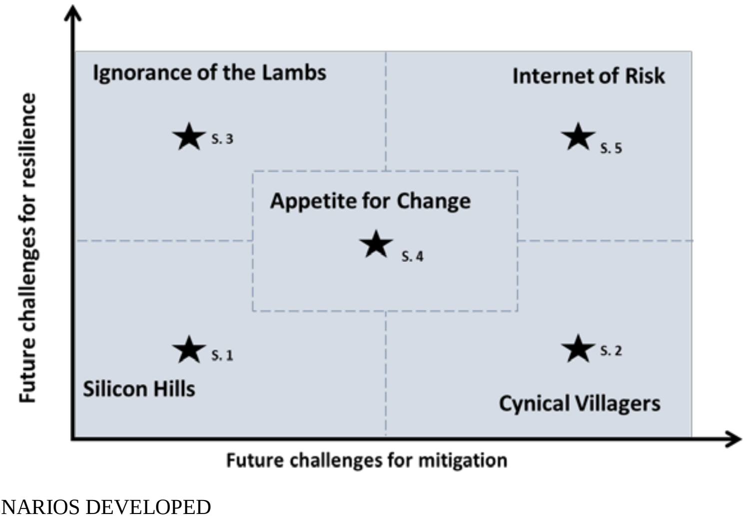
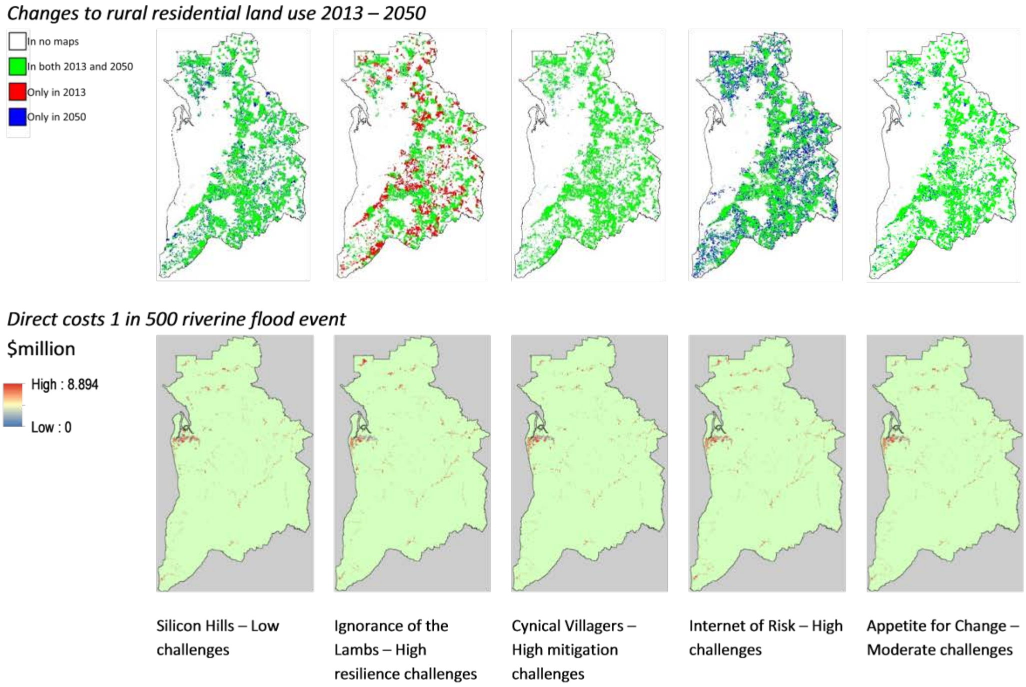


FIGURE 3. SCENARIOS DEVELOPED

The five scenarios were quantified and presented to the stakeholder group, highlighting the five plausible futures for Greater Adelaide in terms of socioeconomic development through the land use model outputs, and also risk profiles across the various modelled hazards. Figure 5 highlights the changes in rural residential land uses between 2013 and 2050, along with the calculated damage from 1 in 500 riverine flood events in 2050 for illustration purposes.

This extended abstract provides a brief overview of the SDSS, and its development and application for Greater Adelaide. The SDSS is able to account for long-term risk through considering the dynamics in hazard, exposure and vulnerability, along with a use process that emphasizes the exploration of plausible futures and what impacts various trends have on risk profiles. The analysis of risk reduction can be coupled with cost-benefit analysis and socioeconomic environmental values and impacts to provide a more holistic view of the utility of various mixes of risk reduction options. Given risk management has very strong social and environmental dimensions, it is hoped the SDSS can lead to more transparent and robust policy settings and decision making.



Silicon Hills – Low challenges

Ignorance of the Lambs – High resilience challenges

Cynical Villagers – High mitigation challenges

Internet of Risk – High challenges

Appetite for Change – Moderate challenges

FIGURE 4. SELECTED MODEL OUTPUTS FOR THE FIVE SCENARIOS.

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