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Final report

Adapt between the flags:

enhancing the capacity of Surf Life Saving Australia to cope with climate change and to leverage adaptation within coastal communities

Marcello Sano, Russell Richards, Oz Sahin, Shauna Sherker, Daniel Ware and Rodger Tomlinson

ADAPT BETWEEN THE FLAGS

Enhancing the capacity of Surf Life Saving Australia to cope with climate change and to leverage adaptation within coastal communities

Griffith University and Surf Life Saving Australia

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The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government, business and in vulnerable sectors and communities to manage the risk of climate change impacts.

Cover images
Kingscliff Surf Life Saving Club, picture by Marcello Sanò

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List of abbreviations

- ABFlags: Adapt Between the Flags
- AOC: Assets, Operations, Community
- BBN: Bayesian Belief Networks
- CLD: Causal Loop Diagram
- CPT: Conditional Probability Tables
- GMB: Group Model Building
- NSW: New South Wales
- Qld: Queensland
- SD: System Dynamics
- SEQCARI: South East Queensland Climate Adaptation Research Initiative
- SLR: Sea level rise
- SLS: Surf life saving
- SLSA: Surf Life Saving Australia
- SLSC: Surf Life Saving Club
- SNA: Social Network Analysis
- Tas: Tasmania

ABSTRACT

Surf Life Saving Australia (SLSA) has assets and facilities exposed to climatic drivers that are on the frontline of climate change, including 310 separately incorporated local surf life saving clubs (SLSCs) and more than 150,000 trained volunteers delivering services on the coastline.

Using a case study approach, the objective of this research project was to employ a range of methods to identify climate change adaptation options and to explore adaptive capacity and pathways for its enhancement, combining stakeholder engagement, Systems Thinking, System Dynamics and Bayesian modelling within five case studies: Currumbin SLSC and North Kirra SLSC, south-east Queensland; Cudgen Headland SLSC, north-east New South Wales; Ulverstone SLSC, northern Tasmania; and SLSA national office, Sydney.

A series of workshops involving surf life savers, local council and community representatives were run, focusing on asset management, life saving operations and the role of local clubs in increasing community resilience.

This first round of workshops was the base to identify relevant adaptive responses. For clubs, these included the defence of current assets, their relocation and retreat, or the improvement of life saving operations through training and equipment upgrades. At the national level adaptation responses included improving partnerships with external organisations, building capacity of the national organisation to provide guidance for clubs and mainstreaming climate adaptation in current procedure.

The second round of workshops was centred on a Bayesian belief modelling exercise to identify adaptive capacity determinants to implement the most relevant options, such as type of funding (local government, state government, club revenue, memberships, etc.) knowledge and expertise in developing options, and community or government will for change. In general, adaptive capacity determinants fell into three categories: (i) funding, (ii) technical knowledge and (iii) social and institutional networks.

Finally, the adaptive capacity determinants identified across case study areas were the base to determine a set of ten actions to enhance the adaptive capacity of surf life saving in Australia.

EXECUTIVE SUMMARY

Surf Life Saving Australia (SLSA) is a national organisation coordinating more than 300 Surf Life Saving Clubs (SLSCs) around the coast of Australia, with more than 150,000 volunteers providing water and beach safety services for Australian coastal communities. While the original activities of SLSCs are beach patrols and surf life saving sport training, today's clubs offer a range of social activities and commercial operations serving coastal communities around the country. For operational reasons, SLSCs are built close to the shoreline, with 63% of them situated within a zone of potential instability (Elrick et al. 2011). Because of the location of a large proportion of SLSCs on unstable shorelines, the risks posed by a range of current and future coastal hazards such as extreme erosion, inundation and sea level rise and the need for climate change adaptation are very real. Throughout the project the phrase 'canary in the coal mine' was frequently raised.

Project objectives

The main objectives of the project Adapt Between the Flags (ABFlags), funded by the National Climate Change Adaptation Research Facility with cash and in-kind support from SLSA, are to explore adaptation options and enhance the capacity of SLSA and selected clubs to cope with and adapt to the risks posed by climate variability and change. More specifically, the project's objectives are:

1. To assess the adaptive capacity of SLSA at the national level and identify options to enhance this capacity internally and in collaboration with allied national level organisations
2. To identify the adaptive capacity of selected SLSCs used as case studies and options to enhance their capacity internally and in collaboration with local government, allied emergency services agencies and community organisations (Currumbin SLSC, Qld; Kingscliff SLSC, NSW; Ulverstone SLSC, Tas)
3. To provide a model of enhancing SLSC adaptive capacity to be implemented across the SLSCs network with a priority of the 63% of clubs in a zone of potential instability and explore the capacity of SLSA to leverage coastal communities' resilience to climate change.

Project activities

The project team from Griffith University (GU) and SLSA has employed established techniques to scope climate change adaptation options and to assess adaptive capacity, combining stakeholder engagement, Systems Thinking, System Dynamics and Bayesian modelling techniques, engaging with stakeholders in four case study areas. Activities include:

- Literature review
- Development of methodology for testing
- Stakeholder identification and engagement
- First round of workshops
- Survey on climate change and adaptation and social networks
- Structural Analysis of conceptual models
- Identification of adaptation options for testing
- System Dynamics modelling
- Second round of workshops

- Bayesian modelling
- Sensitivity testing to identify adaptive capacity determinants and pathways
- Summary of case study outcomes designed specifically for an end-user audience
- Fact sheets on coastal hazards and adaptation options relevant at the national level.

These activities were tailored and tested at eight workshops using four case studies:

- Cudgen Headland SLSC (NSW), workshops on 24/04/12 and 22/10/12
- Currumbin SLSC (Qld) workshop on 04/05/12
- Ulverstone SLSC (Tas) workshops on 19/04/12 and 08/11/12
- SLSA Sydney (NSW) workshops on 15/05/12 and 29/11/12
- North Kirra SLSC (Qld) workshop on 11/12/12.

North Kirra SLSC was used as an additional case study area to replace lack of information from Currumbin SLSC, where we were not able to complete the second workshop.

Project outputs

Main project outputs are:

1. The development and testing of a state of the art methodological procedure to apply systems techniques to a range of case study typologies, focusing on the identification of adaptation options and adaptive capacity determinants
2. The description of a range of case studies in terms of physical assets, day-by-day operations and community interactions and how climate change may affect these, including the possible adaptive responses; and from these case studies, identification of adaptive capacity determinants
3. Models to identify relationships between these determinants, using Structural Analysis, System Dynamics modelling and Bayesian modelling
4. In-depth stakeholder analysis, including stakeholder opinion survey and exploration of social networks
5. Four peer reviewed publications (in preparation), nine contributions to conference presentations in 2012, two conference presentations in 2013.

Adaptation options and determinants of adaptive capacity

The table below reports the most relevant issues, adaptation options and adaptive capacity determinants for the case study areas. These were derived from the two rounds of workshops carried out during the project.

Most relevant issues, adaptation options and adaptive capacity determinants for the case study areas

CASE STUDY	MAIN ISSUES	POSSIBLE ADAPTATION OPTION	ADAPTIVE CAPACITY DETERMINANTS
Cudgen Headland SLSC	Coastal erosion	Defend – Protection of clubhouse	Government funding, engineering design, knowledge, stakeholder management
		Planned retreat – remove clubhouse	Funding, council rate base, implications for water safety
		Improve water safety operations	Capacity of training, number of volunteers, surf life saving culture
Currumbin SLSC	Accessibility during storms, storm and sea level rise proofing	Accommodate storms and sea level rise – improve SLSC design	N/A
Ulverstone SLSC	Future erosion, storm tide inundation	Planned retreat – remove clubhouse	Inertia and will, funding, especially external
		Defend – Protection of clubhouse	Knowledge and expertise, funding opportunities
		Improve water safety operations	Experience of volunteers, clubhouse design and accessibility
North Kirra SLSC	Operations	Operations	Trained members, equipment, club revenue
SLSA	Operational knowledge to support clubs, reputation and membership	Improve partnerships	Relationships, connections, reputation, operational experience
		Mainstreaming climate change in operations and procedures	Proactive attitude, capacity of inclusion in core business, member education awareness
		Capacity building	Network, communication, membership base, funding

Enhancing adaptive capacity of Surf Life Saving Australia

The above adaptation options and adaptive capacity determinants were used by the project team to synthesise a set of ten actions that can be used as a reference to enhance the adaptive capacity:

1. Create mechanisms to access coastal-hazards funding sources
2. Provide access to alternative equipment to keep operations at the beach
3. Improve fundraising mechanisms at the club level
4. Provide information to the community about existing adaptation options

5. Integrate coastal hazards and climate change in surf life saving training programs
6. Promote training programs within local coastal communities
7. Identify possible innovations in equipment. Equipment shortages and risks under a changing climate should be considered at the club level
8. Mainstream climate adaptation into national operations
9. Improve communication with clubs. Clubs should be informed of the risks posed by climate change and of possible options to tackle the problem
10. Build relationships with national organisations dealing with coastal hazards and climate change.

Future activities

Currently GU has supported its partnership with SLSA by providing additional funds under the GU Industry Collaborative Scheme. These funds will be used to set the basis for a future project under the ARC Linkage program to be submitted in November 2013. It is anticipated that the second research project may include activities related to:

1. Development of a decision support system for climate adaptation of surf live saving clubs
2. Variability and change of extreme storms, operations and assets management
3. Role of SLSA in coastal community resilience
4. Training and capacity building in coastal hazard management for clubs.

Detailed research priorities will be identified with SLSA in the coming months.

1. OBJECTIVES OF THE RESEARCH

The project has been designed around three objectives aimed at generating knowledge of the adaptive capacity of surf life saving clubs (SLSCs) and Surf Life Saving Australia (SLSA) to adapt to climate change.

1.1 Background

SLSA has assets and facilities exposed to climatic drivers that are on the frontline of climate change hazards, including 310 separately incorporated SLSCs and more than 150,000 trained volunteers delivering services on the coastline. SLSA recognises that the challenge posed by climate change is significant and that individual clubs will bear the brunt of climate change impacts. In response, SLSA developed a high level strategy to help guide the organisation called *Impact of Extreme Weather Events and Climate Change on Surf Life Saving Services: A Road Map for Adaptive Action* (Elrick et al. 2011) The Road Map reviewed the vulnerabilities of SLSA and of specific SLSCs' facilities and infrastructure around Australia's coast and also highlighted the need for SLSA to act on climate change issues as an organisation. The size of the problem for SLSA and Australia's coastal communities is significant. In fact, 63% of SLSA's 310 clubs are located within zones of potential instability. The Road Map generated large media interest and coverage in November of 2011 on ABC News, Gold Coast Bulletin and Sky News..

The project Adapt Between the Flags (ABFlags) seeks to provide a better understanding of these problems at the club scale and for SLSA as a national organisation. For this purpose, case studies were carried out, initially with Currumbin SLSC, south-east Queensland (Qld); Cudgen Headland SLSC, north-east New South Wales (NSW); Ulverstone SLSC, northern Tasmania (Tas); and SLSA national office, Sydney; with the addition of North Kirra SLSC, south-east Qld during the project. The NCCARF Synthesis and Integrative Research Program call presented the opportunity to apply Systems Thinking and modelling techniques to the case studies, by focusing in particular on the use of Bayesian Belief Networks (BBNs) for the analysis of adaptive capacity. In the period 2010–2012, as part of the South East Queensland Climate Adaptation Research Initiative (SEQCARI, CSIRO 2011), members of the project team commenced development and testing of participatory methods for exploring the adaptive capacity of communities, sectors and industries, such as coastal communities, the energy sector and natural resource management organisations. Involved researchers include Dr Marcello Sanò and Dr Russell Richards from Griffith University, coordinated by Prof. Tim Smith, University of the Sunshine Coast. The developed approach aimed at shifting from linear, hazard-based approaches to complex integrative system approaches (Füssel 2007), integrating methodological frameworks such as Systems Thinking (Ison 2009; Sterman 2000; Senge 1990; Checkland 1981; Forrester 1968) and Bayesian approaches (Varis and Kuikka 1997; Charniak 1991). Both of these frameworks are suited to exploring climate change adaptive capacity because they facilitate the direct involvement of stakeholders, cater for both deductive and inductive logic and explicate mental models to address probable, causal relationships. They are also complementary methodologies. Systems Thinking provides a framework for systems practice, a way of thinking holistically about real problems and modelling complex systems using specific tools (Sterman 2000), while BBNs can explicitly account for uncertainty, even when limited by sparse datasets, by eliciting qualitative variables through 'expert opinion' (Castelletti and Soncini-Sessa 2007; Charniak 1991). Hence, Systems Thinking can be used to conceptualise the key determinants of adaptive capacity and options to enhance it, while BBNs can then be used to address probabilistic causality between these variables by means of models and simulations. This approach has been demonstrated as suitable to explore the

adaptive capacity of industry and business (based on a successful workshop with ENERGEX, the largest energy provider in south-east Queensland, SEQ) and was selected to explore adaptation options and the adaptive capacity of SLSA and selected SLSCs.

1.2 Objectives

Objective 1
Identify the adaptive capacity of SLSA at the national level and options to enhance its capacity internally and in collaboration with allied national level organisations

We identified the determinants of adaptive capacity for SLSA using a BBN approach elaborated during workshops and additional in-house sensitivity testings. These adaptive capacity determinants (enablers and constraints) are listed and described in sections 3.4 and 4.3 of the report.

Objective 2
Identify the adaptive capacity of selected SLSCs used as case studies and options to enhance their capacity internally and in collaboration with local government, allied emergency services agencies and community organisations (Currumbin SLSC, Qld; Kingscliff SLSC, NSW; Ulverstone SLSC, Tas)

We identified the determinants of adaptive capacity for selected clubs using a BBN approach elaborated during workshops and additional in-house sensitivity testings. These adaptive capacity determinants (enablers and constraints) are listed and described in section 4.3 of the report.

Objective 3
Provide a model of enhancing SLSC adaptive capacity to be implemented across the SLSCs network with a priority of the 63% of clubs in a zone of potential instability and explore the capacity of SLSA to leverage coastal communities' resilience to climate change

A set of ten actions for improving the adaptive capacity of SLSA is reported in section 4.3. In addition to this, during the project SLSA and the research team identified the need to focus on developing a product relevant to end users in the form of a decision support tree to enable clubs to access information relevant to the hazards they face. As a response to this need, we developed a decision support system which combines the synthesis of this report with broader coastal hazard and climate change information.

2. RESEARCH ACTIVITIES AND METHODS

2.1 *Research activities*

Completed research activities in this report are those included in the initial project proposal, either using the intended or more sophisticated approaches, as well as some additional activities, based on the in-kind contribution of other researchers involved, as described in the table below (Table 1).

The second workshop in Currumbin SLSC was not carried out due to the lack of engagement from stakeholders from that club. No response has been received to a number of emails and calls to run a second workshop. In partial replacement to this, we ran a Bayesian modelling exercise with North Kirra SLSC (Qld) focused on surf life saving operations.

Table 1: Summary of research activities

RESEARCH ACTIVITY	INVOLVED RESEARCHERS	ORIGINAL/ADDITIONAL AND COMMENTS
Literature review	Sanò, Richards, Sahin, Ware, Brighton, Sherker	Original
Development of methodology for testing	Sanò, Richards, Sahin	Original
Stakeholder identification and engagement	Ware, Sanò	Original
First workshops	Sanò, Ware, Sherker	Original
Survey on climate change and adaptation and social networks	Ware, Sanò	Additional activity
Structural Analysis of conceptual modelling	Sanò	Original
Identification of adaptation options for testing	Sanò, Tomlinson	Original
System Dynamics modelling	Sahin, Sanò	Additional activity
Second workshops	Sanò, Richards, Sahin	Original
Bayesian modelling	Richards, Sanò	Original
Sensitivity testing to identify adaptive capacity determinants and pathways	Richards, Sanò	Original
End-user friendly summary of case study outcomes	Sanò	Original
Fact sheets on coastal hazards and adaptation options relevant at the national level	Sanò	Original

2.2 *Literature review*

This project has combined a range of systems techniques to identify stakeholders, develop conceptual models of climate impacts and responses, run dynamic simulations of future scenarios and identify adaptive capacity determinants. These techniques include Social Network Analysis (e.g. Prell et al. 2009), Systems Thinking (e.g. Senge and Sterman 1992), System Dynamics (e.g. Sterman 2000) and Bayesian modelling (e.g. Castelletti and Soncini-Sessa 2007). Systems Thinking can be used to provide an overview of the system's structure and the connections between climatic and non-

climatic pressures, impacts on the case studies and possible adaptive responses. Further analysis and simulations can be used to explore the systems model and to identify key components of the system. Bayesian modelling will be centred on the identification of adaptive capacity determinants for specific adaptive responses. The outcomes of this analysis are relevant to the decision-making process. While the modelling approaches described above do not provide exact solutions *per se*, they are useful to orient the decision-making processes.

This literature review covers (i) reports and literature relevant to SLSA in a changing climate; (ii) elements of adaptation and adaptive capacity to climate change; (iii) stakeholder engagement and Social Network Analysis; (iv) systems science and Systems Thinking; (v) System Dynamics modelling; and (vi) Bayesian modelling.

2.2.1 Surf life saving and climate change

With a long history and tradition of more than 100 years, the surf life saver has a unique role in Australia's culture: to save lives and prevent injuries for people who visit Australia's beaches. Many Australians choose to be part of this culture and so surf life saving is one of the largest volunteer organisations in the country. With more than 150,000 trained volunteers delivering services on the coastline, surf life saving in Australia provides a fundamental safety service to Australia's beach users. For instance, in 2010 surf life savers rescued approximately 12,000 people and avoided a further 6,000 rescues and approximately 600 drowning deaths across Australia thanks to the volunteer patrol hours delivered, valued at approximately AU$165 million. The total value of surf life saving across Australia is approximately AU$3,412 million in avoided injuries, permanent incapacitations and deaths (PricewaterhouseCoopers 2011).

SLSA has assets and facilities situated in close proximity to the coastal zone. These assets, including 310 separately incorporated local SLSCs, are exposed to extreme storms, sea level rise and other climate change impacts and are at the frontline of the impacts of climate change. Recently there have been some specific examples of SLSA services affected by erosion events. For instance:

- The Moore Park Beach SLSC (Qld) was damaged in February 2010 with strong seas washing away the sand from under a supporting wall, causing part of the foundation to collapse. The club has been given permission to demolish and replace the damaged clubhouse. The new clubhouse will be situated 50 m back from the beach (Derry 2010).
- Kingscliff Beach and Cudgen Headland SLSC (NSW), one of our case studies, recently suffered from a major erosion event (Figure 1). While the causes of erosion are under study, the consequences have been dramatic, with damages to the surf club and surrounding areas, including the loss of parts of the caravan park. Approval has been granted for a 260 m, AU$500,000 rock wall to be erected to protect the most affected coastal stretch from further erosion (Todd 2012).

Figure 1: Kingscliff's Cudgen Headland SLSC in 2012

Photo: Marcello Sanò

SLSA has recently commissioned a detailed report in an effort to organise strategies to reduce vulnerability to the impacts of climate change and extreme weather events (Elrick et al. 2011). Evidence shows that SLSCs face different levels of vulnerability to projected climate change impacts based on their relative biophysical and socio-economic characteristics. Some clubs are situated in areas exposed to coastal erosion

processes, while others do not have the human or financial resources required to support adaptation. This differential vulnerability requires a tailored rather than a 'one size fits all' approach. The study identified a list of eleven adaptive actions to achieve a higher degree of resilience for SLSA and its clubs. Six of these actions (1, 4, 5, 6, 7, 11, in **bold** below) are relevant to the scope of ABFlags (Table 2).

Table 2: Adaptive actions identified by Elrick et al. (2011) and the role of ABFlags's research program

ADAPTIVE ACTION	RATIONALE FOR INCLUSION IN ABFLAGS
1. Strengthen partnerships with organisations to share and access information that supports coastal management and climate change adaptation	**ABFlags's stakeholder identification and engagement at local clubs, testing of stakeholder mapping and Social Network Analysis**
2. Enhance communication across the organisation through development of a communication plan	Not in the scope of the project
3. Enhance clubs' access to information that will raise awareness by publishing information on readily accessible locations, such as the Ecosurf website	Not in the scope of the project
4. Promote on-ground adaptive action by identifying case studies of good practice, such as management actions to reduce the impacts of extreme events or long-term chronic beach change	**ABFlags's workshops and data analysis are designed to identify adaptive responses and adaptive capacity determinants**
5. Mainstream climate change into operational procedures to facilitate integrated management of climate risks	**ABFlags's workshops and data analysis are designed to identify adaptive responses and adaptive capacity determinants**
6. Undertake awareness raising activities to enhance organisational commitment to addressing the impacts of climate change	**ABFlags's stakeholder engagement and workshops will enhance organisational commitment**
7. Assess the vulnerability of SLSCs to climate change (through completion of a first pass vulnerability assessment) to (i) understand differential exposure and capacity; and (ii) provide case for financial support to aid adaptation	ABFlags's workshops and data analysis are designed to identify adaptive responses and adaptive capacity determinants
8. Establish mechanisms to monitor the impacts of climate change and other risks across the organisation (i.e. a climate risk reporting framework)	Not in the scope of the project
9. Identify funding sources to provide dedicated financial support for adaptive action and establish criteria for equitable dispersal of funding	Not in the scope of the project
10. Investigate opportunities to establish coordinated support systems for clubs to access in times of emergency and to support long-term planning	Not in the scope of the project
11. Assess the adaptive capacity of SLSCs to facilitate the delivery of targeted support based on individual needs	ABFlags's workshops and data analysis are designed to identify adaptive responses and adaptive capacity determinants

2.2.2 Climate change adaptation and adaptive capacity

Climate adaptation is generally defined as an ‘adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities’ whereas adaptive capacity is considered the ‘ability to adjust to climate change, to take advantage of opportunities, or to cope with the consequences’. Understanding the adaptive capacity of a given system is critical to assess its overall vulnerability, defined as ‘a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity’ (IPCC 2007).

Identifying climate change adaptation options and understanding the adaptive capacity to implement these options is critical for organisations or institutions involved in the adaptation process. Sophisticated research has been recently published on the adaptation process of environmental management regimes (e.g. Young 2010) complex regions, such as the New York metropolitan area (e.g. Rosenzweig et al. 2011) or other public sectors such as water management (e.g. Huntjens et al. 2012), forest management (e.g. Spittlehouse 2011) or coastal management (e.g. Tobey et al. 2010). Accounting for climate change trends is a relatively new consideration for most non-government organisations and the private sector; however, research is being carried out to understand, conceptualise, and respond to its impacts (Winn et al. 2011; Berkhout et al. 2006). In this sense SLSA has been proactive by producing a comprehensive study on the impact of climate change on its services (Elrick et al. 2011).

While conceptual essays on adaptation and adaptive capacity are common in the literature (Pahl-Wostl 2009; Smit and Wandel 2006; Adger et al. 2005), the practical identification of adaptation options and adaptive capacity determinants has not often been addressed in practice. This can be carried out using participatory techniques such as Scenario Planning (Low Choy et al. 2011; Tompkins et al. 2008), Systems Thinking (Sanò et al. 2010b) and Bayesian modelling (Richards et al. 2012). These techniques often rely on stakeholder engagement.

The purpose of the ABFlags project is to identify adaptation options and adaptive capacity determinants for SLSA and SLSCs, using a range of systems techniques presented in this literature review and applied to different case studies. The concepts of adaptation and adaptive capacity will underpin the project activities; however, simplified concepts will be used for communication purposes, for example, the use of words such as ‘solution’ and ‘response’ instead of ‘climate adaptation’ or the use of ‘ability’, ‘constraints’, ‘enablers’ or ‘resources’ instead of ‘adaptive capacity’.

2.2.3 Stakeholder identification and engagement

This activity is critical to identify and engage with stakeholders and run workshops at the club level and national level of SLSA.

In public management, a stakeholder is an individual, group or organisation who must be involved and consulted to implement initiatives that could affect their interests. A similar definition is used in business where stakeholders may affect or be affected by the achievement of a private organisation’s objectives (Freeman 2004). In complex socio-ecological systems where multiple interests apply, bringing together the right people (the key stakeholders) is a way of building consensus, to avoid early-stage conflicts, to push the process forward against delays and to promote initiatives that share decision-making responsibility. The chance of acceptance of change will generally be increased if stakeholders have been included and have a sense of ownership of the process. In this sense, the process of engaging stakeholders

represents a minor expenditure of resources when compared with the costs of poor performance, or even disaster, that typically follows in the wake of failing to attend to key stakeholders, their interests and their information (Bryson 2004).

Initiatives may fail in large part because decision makers fail to deal with the interests of key stakeholders. Failure includes non-implementation, partial implementation or poor results (Nutt 2002). Failure is therefore associated with the lack of recognition of complex problems with multiple facets, each of particular concern to a specific group of people: the involvement of these people and the exploration of their problems and objectives can be a decisive factor for the success of a new initiative.

Stakeholder analysis is an approach and procedure for gaining an understanding of a system by identifying the key actors or stakeholders in the system, and assessing their respective economic interests in that system (Grimble and M-K Chan 1995). This approach has been applied to a number of contexts with similarities to our project (Areizaga et al. 2011; Sanò et al. 2010a; Gunton et al. 2010; Pomeroy and Douvere 2008).

Adaptation to climate change poses a series of challenges that differ from traditional stakeholder engagement approaches applied to coastal management problems. In particular, challenges such as preparing for future impacts while dealing with current pressures add complications such as long time horizons and the uncertainty associated with the distribution of impacts. Stakeholder analysis should be adopted to better address changing stakeholder preferences, and awareness of the trade-offs inherent in any decision (Tompkins et al. 2008).

SLSA and affiliated clubs operate within the coastal zone, a complex natural, socio-economic, and administrative system. Understanding stakeholder interests and needs is a critical process when developing management strategies such as those required for the adaptation to climate change of surf life saving assets and operation.

The process of identifying stakeholders who have a real interest and who can influence and/or bring in useful proposals is a specialist task, and different approaches can be adopted. Typically, researchers run iterative processes that may include review of grey literature, discussions with the local councils and site visits where existing contacts are used to identify other stakeholders (Tompkins et al. 2008). An alternative approach is the so-called Hydra model (one head generates more heads – that is, one stakeholder generate more stakeholders) where key stakeholders are identified in an iterative process starting from the problem owner and finishing when stakeholders identify each other, usually after three rounds (Sanò et al. 2010a). This approach provides a structure to systematically work through to avoid omitting any key individuals or groups and was adopted in this research. Opening up an active participation process to any private citizen can sometimes generate greater confusion and not support reaching a consensus. Classification and prioritisation of stakeholders can be used to address this issue so that only the key stakeholders are selected, to optimise participatory activities and push the process forward. For instance, Areizaga et al. (2012) suggest subdividing stakeholders into these categories: (i) dependent (who live and/or work on the coast, e.g. coastal residents, fishers, the maritime sector), (ii) influent (whose interests lie on the coast, e.g. environmentalists), (iii) responsible (those who have responsibilities for its management), and (iv) users (groups using coastal resources but with low levels of dependency, e.g. beach users, swimmers, surfers). Fletcher (2007), on the other hand, identified 11 categories of stakeholder and recommends considering at least two representatives from each of the following categories: business, government departments, individuals, local authority members, local authority officers, local special interest groups, national agencies, national coastal forum, non-government

organisations, operational authorities, and sectoral groups. Further to this categorisation it is also possible to categorise the constituency or representation as the basis for selection as follows: trustee (empowered to make decisions on behalf of constituency); delegate (channel of communications only); and mandate (working to a mandate or agenda). This project did not employ a formal classification of stakeholders, as it was not within the scope of the research. However, this information is relevant as it sets the basis for further research to be carried out with the project industry partner, SLSA.

2.2.4 Social Networks

Stakeholder identification and engagement processes can be improved by integrating Social Network Analysis (SNA) techniques, which can be applied to natural resource management (Bodin and Crona 2009; Prell et al. 2009, 2008; Bodin et al. 2006) coastal management (Marín and Berkes 2010; Olsson et al. 2008) and climate adaptation (e.g. Pahl-Wostl 2009). Social networks have been shown to have significant influence on the behaviour of groups and individuals (Dempwolf and Lyles 2011). SNA considers a series of individual actors as *nodes* and the nature of their relationships as *ties* (Butts 2008).

Within SNA the unit of analysis is the network itself, and a distinction is made between ego and complete networks (Bodin and Prell 2011). Ego networks are an individual ('ego') and others ('alters') that the ego identifies based on a specific premise (e.g. which individuals do you collaborate with in your work with Ulverstone SLSC?). Ego networks are contrasted with the idea of a complete network, which considers all individuals within a boundary, such as the members of a particular SLSC. This is an important distinction for the types of analysis, with ego network analysis focused on how individuals perceive their networks and comparisons across individuals. In contrast, analysis of individuals or nodes within complete networks is concerned with centrality, that is, the relative importance, prestige or power of each individual. Network positions incorporate centrality parameters (Hulst 2008). A number of distinctions/types of centrality have been recognised; however, Prell et al. (2009) state that only two, 'degree' and 'betweenness' centrality, have relevance to natural resource management situations. 'Degree centrality refers to how many others a stakeholder is directly connected to' (Prell et al. 2009; p. 509); such nodes may be important for distributing information and mobilising others, but the energy required to maintain a high number of ties is thought to reduce their strength, which may reduce the influence of high degree centrality nodes. Betweenness centrality is defined as 'how many times an actor rests between two others who are themselves disconnected' (Prell et al. 2009; 509). These stakeholders bring together disconnected segments and are thought to play the role of knowledge brokers.

The other parameter of network positions is tie strength, a measure of the connection between two nodes, which is thought to be a linear combination of the time period of a relationship, the frequency of contact (intensity) and intimacy (mutual confiding) and the reciprocity of the tie (Granovetter 1973). The ties between individuals can be represented by lines, with or without arrows. The arrows enable representation of either senders (or individuals who nominate) and receivers (or nominees) as well as mutual or reciprocal relationships where both nodes have recognised the other.

Actors sharing a strong tie tend to '(i) influence one another more than those sharing a weak tie; (ii) share similar views; (iii) offer one another emotional support and help in times of emergency; (iv) communicate effectively regarding complex information and tasks; and (v) be more likely to trust one another' (Prell et al. 2009; p. 505). SLSCs

provide a meeting place, which brings together community members from different organisations for a shared purpose that may be a conduit for building ties.

Weak ties also tend to play important roles within social networks as they tend to link otherwise dissimilar individuals and as a result can be important for facilitating transfer of innovations (Granovetter 1973). The challenge to be overcome, however, is that weak ties tend to lack trust and can be broken relatively easily (Prell et al. 2009). When examining a network as a whole, the central question has been, 'How cohesive is this network?' The parameters used in SNA to measure cohesion are density and centralisation.

> *A highly centralized network is one characterized by one or a few individuals holding the majority of ties with others in the network. Centralized networks are helpful for the initial phase of forming groups and building support for collective action. However, research suggests that such centralized networks are disadvantageous for long-term planning and problem solution* (Prell et al. 2009, p. 504).

SLSCs have the potential to reduce the centralisation of social networks within coastal communities by enhancing the number and strength of connections and reducing the reliance on single centralised individuals.

Density measures the difference between the number of potential and actual ties present in a network; a dense network has a high proportion of ties realised and is thought to be more cohesive (Bodin and Prell 2011). By establishing links between individuals and organisations, the SLSCs may be a means to increase the density of a network.

There have been a limited number of studies of social networks associated with coastal management (Scholz et al. 2008; Bodin and Crona 2008). The collective action nature of coastal management shares many similarities with other natural resource management situations that have been studied using SNA providing a wider pool of literature on which to base this research. While it has been shown that networks influence the actions of groups and individuals, there are a number of trade-offs across the different dimensions, which need to be considered when drawing on SNA for natural resource management issues. These trade-offs have implications for selecting stakeholders, designing engagement and for integrating SNA with traditional stakeholder analysis techniques. Examples of the use of SNA in different situations are described as follows:

- Scholz et al. (2008) considered the collective choice challenges of management policy development for 22 estuaries in the United States and by conducting SNA of the participants found that search (access to information/ideas) rather than credibility appears to pose the greater obstacle to collaboration; well-connected centrally located organisations engage in more collaborative activities than those embedded in small, dense networks.
- Holman (2008) examined social networks for a redevelopment project in Portsmouth, England, which demonstrated that this approach can be used to identify network and power imbalances. In addition, the study found that SNA could be used to guide community groups in the development of their relationships to improve their capacity to participate in policy development processes.
- Bendle and Patterson (2010) used SNA to demonstrate that for small regional communities, community organisations were hubs for cultural and artistic endeavours. Given the small scale of the artistic and creative communities,

these organisations were important for maintaining critical mass and drawing together what would otherwise have been isolated clusters.

- Choi and Kim (2007) used SNA to examine power dynamics of emergency management networks before and after changes to network structure. The study found that the intended shift to power dynamics was not achieved by the policy change and demonstrated the potential for SNA as a policy design/analysis tool.
- Lauber et al. (2008) examined social networks related to community-based natural resource management dilemmas and found that SNA could provide insights into stakeholder engagement strategies. The study recommended that social networks structures were most appropriate for informing the staging and design of consultation approaches rather than stakeholder identification and prioritisation.
- Prell et al. (2009) combined SNA with stakeholder analysis in a case study of the management of the Peak District National Park in the United Kingdom. The study found that SNA metrics such as centrality should not be used in isolation to identify and prioritise stakeholders, but rather in conjunction with traditional stakeholder identification methods such as interviews and media analysis.
- Hutton et al. (2011) used SNA to identify reciprocal actor networks within the stakeholder identification stage of a Climate Change Vulnerability assessment for the Upper Brahmaputra River Basin, and the Upper Danube River Basin. The study did not provide any details of the methods or findings of the SNA other than that it was used.
- Newig et al. (2010) used SNA to measure network size, density, cohesion, centralisation, and the occurrence of weak as opposed to strong ties. This analysis was used to determine which characteristics of networks foster collective learning. The study found that certain network characteristics can have different learning-related effects, depending on whether they relate to information transmission or deliberation. Further, they showed that ultimately network structure and learning appear to mutually influence each other, leading to learning cycles.
- Luthe et al. (2012) conducted SNA for governance of the Swiss Gotthard region to identify how networks influence resilience to climate change. The study found a network structure supporting stability, flexibility and innovation increases regional resilience to climate change. However, a low density, uneven distribution of power and a lack of integration of some supply chain sectors into the overall network are key weaknesses that reduce resilience to climate change.
- Rotberg (2010) used SNA for a rural Bangladesh village to determine if influence of key individuals could facilitate adaptation to climate change. The study found that trust, respect and accessibility are the key attributes for influential community members.

2.2.5 Systems approaches

A range of systems techniques have been applied to this project as a way to explore SLSCs and SLSA adaptation and adaptive capacity to climate change. These techniques and their variations are generally suited for the analysis of complex systems and organisations with the aim of looking at the bigger picture of problems, build shared mental models, build consensus and avoid unintended consequences of decisions.

In general, systems science includes different interdisciplinary fields studying the nature of complex systems in nature, society and the economy. A complex system is

composed of interconnected parts that as a whole exhibit one or more properties that are not discernible from those of the individual parts. Examples of complex systems include the atmospheric climate, the world economy or the human body. Systems science fields include, for instance, systems theory, cybernetics, operations research, complex systems, complex adaptive systems, Systems Thinking and System Dynamics. The pillars of systems science include the work of Wiener on cybernetics (Wiener 1948), von Bertalanffy on general system theory (von Bertalanffy 1969) and Forrester in System Dynamics (Forrester 1968). The concepts developed in these early studies are currently applied to numerous fields, including business (Sterman 2000; Senge 1990), sustainability (Alvarez-Arenas and Miron 2006; Hjorth and Bagheri 2006; Reed et al. 2005; S-L Chan and Huang 2004; Shi et al. 2004; Ronchi et al. 2002; Kelly 1998), water management (Khan et al. 2009; Kojiri et al. 2008; Zhang et al. 2008; Smyth and RI Forrester 2000), fisheries (Bald et al. 2006; Utne 2006) and coastal management (Hopkins and Bailly 2011; Kay et al. 2003; Van der Weide 1993).

Holism is the fundamental paradigm informing the systems approach. Holism is based on the idea that all the properties of a given system (biological, chemical, social, economic, mental, etc.) cannot be determined or explained by its components alone; instead, the system as a whole determines to a great extent how the parts behave. This practice is in contrast to a reductionist approach, which aims to understand systems by dividing them into their smallest possible or discernible elements and understanding their elemental properties, each one on its own. The success of science in producing knowledge and of its associated technologies in transforming our world demonstrated that reductionism is the right approach to solve certain types of technological problems. On the other hand, when we are faced with complex real-world problems of societies and organisation, a reductionist approach can lose many emergent properties of the system. Holism and reductionism should therefore be regarded as complementary lenses to explore, understand and modify natural, socio-economic and organisational processes.

Systems Thinking is a framework for systems practice, a way of thinking holistically about problems while focusing on the components and relations of complex systems. Systems thinkers consider the problems as part of the system, not as side effects of decisions. As a consequence, they analyse complex systems through a systematic problem exploration, in order to overcome limitations of individual mental models of reality. Systems Thinking employs a range of techniques to explore complex systems, in particular the use of diagrams to illustrate relationships between variables as a way of representing models of reality, including stakeholders' mental models. A common way of representing these models is the use of Causal Loop Diagrams (CLD), following the formal language proposed by Sterman (2000). The following example, based on pest control in agriculture, shows how CLDs work in Systems Thinking.

An insect eating a crop is controlled through pesticide application and a simple reductionist model would show that the more pesticide applied, the fewer insects will damage the crops. The minus sign represents a negative effect of the first component on the second one (Figure 2).

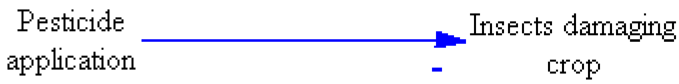


Figure 2: A simple reductionist model

Source: Adapted from Sterman 2000

If we look at the system in a long-term and broader perspective we see that this model only represents part of the picture: the action intended to solve the problem actually makes it worse because the model does not consider the unintended consequences (side effects) which tend to exacerbate the problem. A broader picture of the system shows how insects A in turn control the population of insects B, resulting in a feedback loop where the more pesticide applied the greater the damage to the crop (Figure 3).

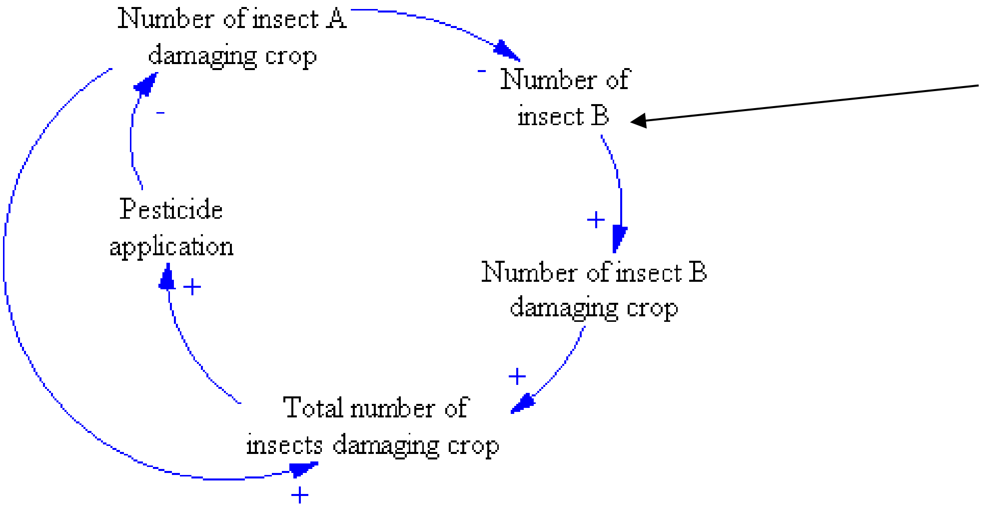


Figure 3: A simple holistic model using a causal loop diagram

Source: Adapted from Sterman 2000

These systems ideas are popularly synthesised in the phrase 'seeing the forest and the trees (the bigger picture)', meaning it is important to understand and learn about systems and, in a participatory environment, to show stakeholders the unintended long-term consequences of their choices. A Systems Thinking approach is therefore useful in multi-actor and complex systems where past solutions could become today's problems: the parts of the system affected by proposed solutions are sometimes not obvious, especially if the system is made up of many components and complex relations.

Systems Thinking can, therefore, be used as a general framework to improve systems learning and understanding, to specify multiple stakeholders' mental models of their surrounding environment. In general terms, a mental model is a representation of reality in a stakeholder's mind. One of the challenges of the Systems Thinking approach is to improve system understanding and to build shared mental models of a given system within a stakeholder group. Acting on a system based on an incorrect mental model can bring important unintended consequences. For instance, Sterman (2008) shows an interesting example of the risk of poor or wrong communication in the consolidation of different mental models of climate change, where the erroneous belief that 'stabilising emissions quickly stabilises the climate' supports wait-and-see policies but violates basic laws of physics. In Sterman's words, a wait-and-see approach works well in simple systems: 'We can wait until the tea kettle whistles before removing it from the flame because there is little lag between the boil, the whistle, and our response' (2008, p. 532). Long delays in the climate's response to anthropogenic forcing means wait-and-see policies will not work. In this context, wrong mental models and poor understanding can drive decision-makers to implement poor policies with little effect on the real problem. In climate change there are substantial delays in every link of a long causal chain, stretching from the implementation of emission abatement policies to

emission reductions to changes in atmospheric greenhouse gas concentrations … when the causal chain reaches global warming, it is already too late.

CLDs can be used to describe positive and negative feedback processes. As shown in Figure 4, they illustrate relationships of cause and effect between the individual system variables that, when linked, form closed loops. Hence, feedback loops can be positive and negative. The overall polarity of a feedback loop is indicated by a symbol in its centre. The arrows show the direction of the causal links between the variables. The polarity marks at the end of the arrows show if the variables at the two ends of an arrow move in the same direction (**+**), or opposite direction (**-**). Thus, the feedback loop on the left is considered to be a positive loop (having a large plus sign) if an increase in a variable, after a delay, leads to a further increase in the same variable. The feedback loop on the right is considered to be a negative loop (having a large minus sign) if an increase in a variable eventually leads to a decrease in the variable. As a consequence, a negative feedback loop yields oscillatory behaviour in a system.

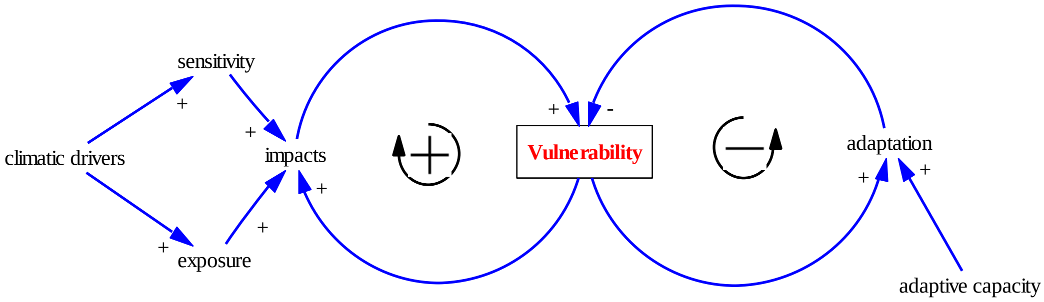


Figure 4: Causal Loop Diagram representing climate change vulnerability

Source: Sahin 2011

In complex, multi-stakeholder environments, systems modelling can be carried out using stakeholder contributions as the base for modelling and simulations. Group Model Building (GMB) refers to a bundle of techniques used to construct systems models, working directly with key stakeholders or experts (Andersen et al. 2007), with the objective of specifying mental models and building a shared mental model based on their contribution. GMB is especially relevant when dealing with the so-called post-science paradigm, when facts are uncertain, values are in dispute, stakes are high and decisions are urgent (Antunes et al. 2006). This technique is particularly suited to address ill-defined strategic issues, often labelled messy problems, that is, situations where there are large differences of opinion on the problem, or even on the question of whether or not there is a problem (Vennix et al. 1999).

A formal step-by-step approach for GMB with stakeholders – connecting problem definition, CLDs and System Dynamics simulations – is proposed by Cavana and Maani (2000) who divide the process into three parts:

1. Problem structuring – identification of the area of concern and of the general objectives, taking into account different stakeholders; collection of preliminary information and data including reports, policy documents, previous studies
2. Causal loop modelling – development of CLDs of the system based on shared mental models identified during the previous phase; the issues identified previously are translated into variables and related to each other using feedback loops
3. Dynamic modelling – translation of CLDs into quantitative diagrams using stocks and flows (this step is formally part of System Dynamics methodologies); simulations using dedicated software allow the identification of behaviour over

time and of the key system variables, to be used as leverages to address system behaviour or redesign the system's structure.

This step-by-step approach was used in the first part of the ABFlags project, where stakeholders were involved in the development of CLDs during workshops. This was followed by in-house dynamic modelling to identify critical elements of the system.

The next sections provide details on System Dynamics simulations.

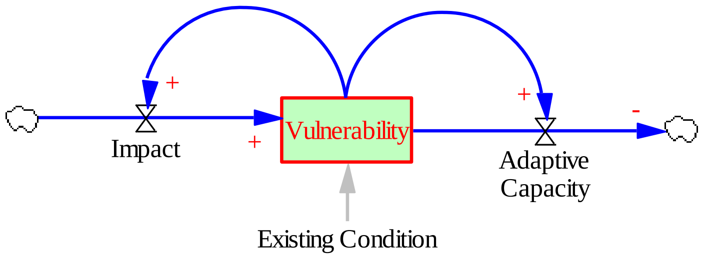
2.2.6 System Dynamics modelling

System Dynamics modelling was used to test adaptation options and behaviour over time for different adaptation options at the club level.

System Dynamics (SD) can be considered part of the Systems Thinking processes whereby quantitative variables and numerical simulations are carried out to analyse the structure and behaviour of a given system. SD started from the idea that models normally used in engineering to test complex processes could be used to improve the understanding of complex social systems. Systems simulations could improve social systems the same way thatfeedback models and cybernetics were improving industrial processes. The evolution in the field, signalled by works in urban dynamics (Forrester 1969) and large-scale experiments on world dynamics (Meadows et al. 1972; Forrester 1971), was a starting point for the development of softer approaches that led to the formalisation of Systems Thinking to overcome issues in simplifying complex realities with numerical models. In parallel to softer approaches, SD models have evolved and are used today to simulate complex systems behaviour in public health (Homer et al. 2007; Cavana and Clifford 2006), energy and the environment (Sterman 2008; Ford 2005; Fiddaman 2002; Fiddaman 1997), irrigation systems and water quality (Gharib 2008; Zhang 2008), climate change impact assessment and adaptation modelling (Sahin 2011; Franck 2009; Marchand 2009; Sahin and Mohamed 2009; Burton et al. 2002) and many other fields.

SD is an approach to understanding the behaviour of complex systems over time. It deals with internal feedback loops and time delays that affect the behaviour of the entire system. Feedback loops are the basic structural elements of dynamic systems that reflect a chain of causal relations among the interacting components of a system. More formally, a feedback loop is a closed sequence of causes and effects, or, a closed path of action and information (Kirkwood 1998). These loops are often linked together and display non-linear relationships that often cause counterintuitive behaviour (Forrester 1996).

CLDs are relevant as a first step in modelling; however, they are unable to capture the levels (stock) and rates (flow) in a system's behaviour (two central concepts of SD theory) (Sterman 2000). Stock and flow diagrams are used to overcome this limitation. Stock and flow represent dynamic relationships between a complex system's variables. A simple stock and flow structure (Figure 5) consists of three different types of elements: stocks, flows and information. The stock, which produces the behaviour in a system, accumulates or depletes, over time. Thus, the stock collects whatever flows into the system, net whatever flows out. For instance, a stock can be the population



number, or, as seen below, vulnerability itself. The flow (here 'impact' and 'adaptive capacity') is the rate of change in a stock; it is measured over a certain interval of time. The flows fill and drain the accumulations. The information link moves from the stock to the flow, as shown by the curved arrow from the stock symbol to the flow symbol.

Figure 5: Stock and flow diagram representation of vulnerability changing over time

Source: Sahin 2011

SD models use differential and difference equations to represent the interconnections within a system. The flows are the functions of the stock and other variables and parameters. A mathematical representation of a stock and flow diagram (Figure 5) is shown below:

Stocks integrate flows (rates of change). That is:

(t)   (t-dt)   (I-AC) dt   Eqn. 1

Where V(t) represents Vulnerability at time t, V(t-dt) shows Vulnerability at time (t-dt), I denotes Impact, and AC refers to Adaptive Capacity

These structures consist of a set of physical and information interconnections generating behaviour of a series of events connected together, over time. SD can be used to analyse how the structure of a physical, biological, or other system can lead to the behaviour that the system exhibits. There are four characteristic patterns of behaviour (Figure 6). They often appear in systems, either individually or in combinations.

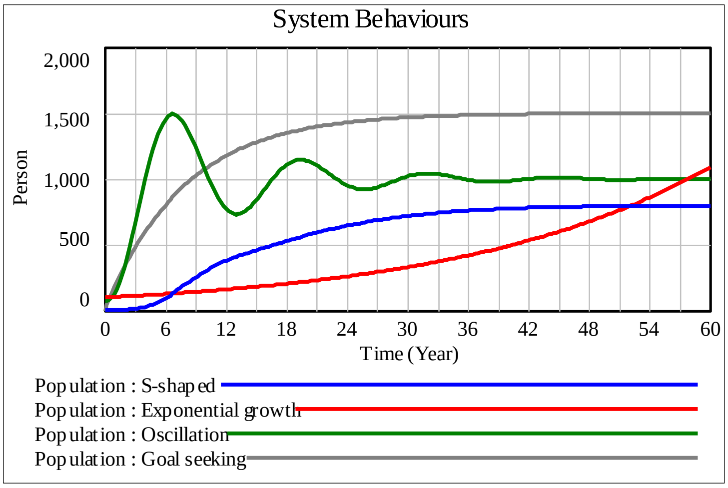


Figure 6: Patterns of behaviour of variables after SD simulation

2.2.7 Bayesian modelling

Bayesian Belief Network (BBN) models were used to explore the adaptation pathways and capacity of SLSA to climate change. BBNs have had widespread use in the area of artificial intelligence (Charniak 1991; Pearl 1988) through research areas such as information navigation and retrieval (Park and Choi 1996; Savoy 1992), medical diagnostics (Spiegelhalter et al. 1993), language understanding (Eizirik et al. 1993) and speech recognition (Lucke 1995). More recently, there has been an emergence of using BBNs for environmental modelling (Uusitalo 2007) including research areas of catchment-drainage (Calder et al. 2008; Castelletti and Soncini-Sessa 2007; Hukkinen 1991), water quality (Barton et al. 2008; Hamilton et al. 2007; Ticehurst et al. 2007; Borsuk et al. 2004) and land-use management (Aalders and Aitkenhead 2006).

BBNs are well suited for achieving the objectives of this project because they provide a formal methodology for amalgamating qualitative and quantitative causal relationships. These relationships can include a combination of social and biophysical variables that have been obtained from a range of sources (e.g. monitoring data, modelling data, expert elicitation) and of different accuracies (Uusitalo 2007). In the context of this project, BBNs provide a structured framework for integrating disparate types and sources of knowledge in data-poor and knowledge-vague settings where there is a reliance on expert opinion (Chaloupka 2007). The importance of this cannot be overstated given that while climate change impacts are typically biogeochemical and physical processes (e.g. sea level rise, ecological regime shifts), human adaptive capacity and adaptation are social processes that are strongly dependent on the perceptions of stakeholders acting within a system (Adger 2003).

Another feature of BBNs is their ability to explicitly account for variability and uncertainty, even when limited by sparse datasets and/or knowledge gaps (Castelletti and Soncini-Sessa 2007; Charniak 1991). This is an attractive attribute given that uncertainty and variability characterise climate change impacts and knowledge (IPCC 2007). This capability is provided by Bayes theory (see equation 2), which provides the mathematics that underpins BBNs. In equation 2, P(A|e) is the posterior probability of observing an event, A, conditioned upon the evidence or data that has already been observed. P(e|A) is the likelihood of observing the data given the hypothesis, and P(A) is the prior probability of observing the event in the absence of data. This formulation allows inference to be made about the probability of an event occurring based upon the data and prior knowledge (expert opinion) about the event.

P(A|e) = P(e|A)*P(A)/P(e) Eqn. 2

BBNs have yet to be widely used to explicitly model social dynamics. Rather, BBNs have typically incorporated only a few (often one) social 'variable', usually as an endpoint and set to a quantitative scale (e.g. Ticehurst et al. 2007). The few examples of where BBNs have been used to explicitly model social dynamics have shown strong utility and practicality in the context of common-pool resource management (e.g. Lynam et al. 2002) and climate change adaptive capacity (Richards et al. 2012).

Developing the model structure and assigning probabilities to the variables within the model, either through conditional probability tables (CPTs; Charniak 1991) or through prior probabilities (see equation 2), are the two critical components of BBN development. In general, the structure of the BBN (variable identification and the connections between them) are typically developed through expert panels (Kjærulff and Madsen 2008). Algorithms for structural learning can be used to build the framework of the model (Myllymäki et al. 2002); however, this computer-learning approach is restricted to data-rich BBNs and has little applicability for social-based models. Rather, in this project, this expertise is provided by the stakeholders involved in the participatory workshops detailed in the methodology component.

The CPT data used to populate the models is often obtained through a combination of monitoring data, model output and expert opinion, typically reflecting the mixture of social and biophysical variables involved. In the context of social dynamics and climate change adaptation, most data in this project was sourced through expert opinion because the data are heavily qualitative and/or have not been measured or modelled. The utility of BBNs for eliciting expert opinion through network development and populating CPTs is well known (Richards et al. 2012; Castelletti and Soncini-Sessa 2007; Uusitalo 2007; Lynam et al. 2002).

The application of BBNs in this project needs to be contextualised within the constraints of these models. BBNs are generally incapable of including feedback loops within the model structure (Hosack et al. 2008). Rather, they (typically) represent the relationships between variables in a hierarchical formation, formally known as directed acyclic graphs (Charniak 1991). Coupled with this, BBNs do not cope well with temporal relationships and therefore the domain of these models is restricted to hierarchical models that are independent of time (Kjærulff and Madsen 2008; Charniak 1991). Conceptually, feedback loops and temporal dynamics can be represented in BBNs (Kjærulff and Madsen 2008), but this rapidly leads to unwieldy models that are difficult to parameterise.

Finally, by convention, the variables within a BBN are generally restricted to discrete variables rather than continuous variables. By definition, this convention is adopted in most BBN models. The rationale is to ease computation of the (BBN) probabilities, to assist in the elicitation of expert opinion and the communication of results (Ames et al. 2005) and to avoid large and intractable CPTs during the latter stage of the BBN development (Marcot et al. 2006). The consequences of taking this approach include needing to ask the questions 'What is the most appropriate level of discretisation?' (i.e. how many 'states' a variable should be represented by) and 'How are these states defined? (Marcot et al. 2006). However, this is a common challenge of developing BBNs and there are formal rules (Marcot et al. 2006) to assist this process. Furthermore, in participatory modelling approaches to model building, these questions can be addressed by the stakeholders themselves (Richards et al. 2012).

2.3 Methods

2.3.1 Overview

The main objectives of this research project are to explore climate change adaptation options and adaptive capacity for SLSA assets and operations and to explore SLSA's role in coastal community adaptation. The methodology employed allowed a systematic exploration of stakeholders, climatic impacts and adaptive responses building on expert knowledge and community contributions, combining a range of techniques such as SNA, Structural Analysis, SD and Bayesian modelling. Two rounds of workshops with stakeholders within four case studies (Currumbin SLSC, Qld; Kingscliff SLSC, NSW; Ulverstone SLSC, Tas; SLSA, Sydney) were held in April/May 2012 and October/November 2012. In addition, we carried out a workshop to explore surf life saving operations at North Kirra SLSC, Qld.

Recently, as part of the SEQCARI (CSIRO 2011), we have started to develop and test participatory methods for exploring adaptation pathways and the adaptive capacity of communities, sectors and industries, such as coastal communities, the energy sector and natural resource management organisations (Richards et al. 2012). The approach aims to shift from linear, hazard-based approaches to complex integrative system approaches (Füssel 2007), integrating methodological frameworks such as Systems Thinking (Ison et al. 2011; Sterman 2000; Senge 1990) and Bayesian approaches (Varis and Kuikka 1997; Charniak 1991).

Building on this experience, this project integrated further elements to better understand the social networks built around SLSA and SLSCs, and to identify critical elements of adaptation and adaptive capacity. New approaches have emerged from the literature review and internal team workshops, namely SNA (see Dempwolf and Lyles 2011 for a review), Structural Analysis (Godet 2006) and SD simulations (Sterman 2000). The project was carried out in five stages:

1. Stakeholder identification and engagement. The aim of this phase was to identify and engage relevant stakeholders in each case study area. The stakeholder engagement process lasted for the whole project. Having a project champion allowed stakeholders to engage in the process. A survey was designed and distributed to stakeholders to gather information on climate change, adaptation options and social networks that may enable the adaptation process.

2. First round of workshops. Problem scoping and Systems Thinking. A first round of workshops were organised for problem scoping and system conceptualisation, using Systems Thinking techniques to identify relevant variables and connections from three groups: (i) drivers, (ii) impacts on assets, operations and community, and (iii) adaptive responses. The conceptual model shows how climate change may affect assets and operations of SLSA at selected clubs and looks into the role of clubs in the community.

3. Data analysis. The first round of data analysis included the validation of the set of variables identified in the first workshop and the identification of relevant relationships using MICMAC Structural Analysis software (MICMAC n.d.).

4. Second round of workshops. Exploration of adaptive capacity. During the second round of workshops, the project team discussed the outcomes of the analysis with the stakeholders and explored the adaptive capacity of stakeholders to implement selected adaptive responses by employing Bayesian

modelling techniques. In addition, stakeholders were involved in a survey on climate change and community relationships based on SNA concepts.

5. Data analysis. The second round of data analysis focused on the analysis of the Bayesian models, using sensitivity testing to identify adaptive capacity determinants.

2.3.2 *Stakeholder Identification and engagement*

The identification and engagement of stakeholders should be systematic, with the help of the project promoter (the so-called 'problem owner', or in our case, the 'project champion'), often a public authority or sometimes a private investor. The promoter should be aware of the importance and the advantages of involving people from the beginning: building consensus around new initiatives often determines their final success.

The methodology employed in the ABFlags project builds on the snowballing sampling approach called Hydra (Sanò et al. 2010a) where each stakeholder identified by the problem owner is asked to identify other potential stakeholders in an iterative process. Depending on the type of project, after a few rounds, all stakeholders are identified. In addition, we developed a survey to better understand the perception of stakeholders around climate change and adaptation issues for SLSCs. In ABFlags this process was replicated in each of the four case studies with the following steps:

1. Indentify on-board project champion: for each of the four case studies a project champion was identified and recruited to act as a liaison between the project team and the case study stakeholders. The project champion was nominated by SLSA and screened by the project team through either face-to-face or phone interview to confirm that they have networks and capacity to successfully champion each case study. Each project champion was brought on board through a briefing and provided with background materials and requests for input.

2. Identify initial stakeholders: working with the project champion, an initial list of stakeholders was identified; these included both individuals and organisations. The brief to project champions was to 'Identify people with local knowledge of the specific physical and social, economic and governance issues that need to be considered when planning for climate impacts in each case study – it could be club members, state and local government officers, politicians, business owners or residents'.

3. Contact stakeholder nominations and invites to workshops: the project team contacted each of the nominated stakeholders by email to introduce the project and seek their commitment to participate, collect details of their sector and interest and details of any other individuals or organisations who they felt needed to be nominated to participate in the two rounds of workshops.

4. Conduct opinion survey on climate change, adaptation and social networks: This survey was used to better understand stakeholder opinion on climate change and adaptation issues and which stakeholders were relevant to this core group (see next section).

5. Explore stakeholder network: the list of initial nominees and the subsequent names provided by the initial nominees using the survey was used to develop a

list of stakeholders. Workshops participants then provided information on their relationship with the identified organisations.

2.3.3 Survey on climate change and social networks

2.3.3.1 Design of the survey

An online survey was identified as a suitable mechanism for data capture given the geographic distribution of the individual clubs and that the preferred means of communication by the clubs and working group members was email. The survey was designed to identify organisations involved in beach and foreshore management, recreation and safety within case studies by collecting data on their networks. The survey used a single instrument to collect responses from all three case studies and from individuals as representatives of organisations regardless of their involvement in the initial workshop. The survey was developed using Qualtrics, an online survey design and data collection tool (Qualtrics n.d.). The Qualtrics platform enabled the use of sophisticated survey flow programming, which enabled a single instrument to be used regardless of the respondent's case study or status within the project. Given the complexity of distribution described below, having a single instrument to promote to all survey respondents was an important feature.

The survey comprised four sections:

1. Introduction and consent
2. Climate change and beach and foreshore recreation and safety
3. Social network – name generator and relationship classification
4. Demographics.

A copy of the survey is provided in Appendix 1.

2.3.3.2 Analysis of social network structure

The social network structure was analysed using a simple method in which stakeholders involved in the workshop were asked to provide information on the strength of their relationship with relevant organisations from 0 to 3, where 0=no relationship and 3=strong relationship. Stakeholders were classified based on the number and strength of their relationships.

2.3.4 First round of workshops – Problem scoping and Systems Thinking

The first round of workshops was held in April/May 2012 in the four case study locations. Each workshop commenced with the participants being provided with contextual information regarding the research. This included project aims and an overview of issues related to climate change in their area or sector of concern. For example, information on extreme storms and erosion, coastline evolution and historical shoreline position was presented drawing on the best available information. This briefing was supported by an overview of observed climate variability and climate change projections for the area of study. Simplified, non-technical language was used throughout the workshops. The project team did not use the word/concept 'climate change', in an attempt to disconnect people from mental models relating this issue to Australian political debates (e.g. carbon tax). The word 'element' or 'issue' was used instead of 'variable' and the words 'factor' or 'external factor' were adopted to describe climatic and non-climatic driver variables.

The process started by defining the object of the potential impacts, that is issues or elements describing Assets, Operations and Community (AOC). Four questions were used to trigger the identification of these elements:

- What assets are at stake?
- What operations are at stake?
- How do you engage with the community?
- Do you see any other issue/s related with climatic risks?

A second step was to identify climatic and non-climatic drivers that may affect these issues/elements of the system. We provided an initial list, including:

- Sea level rise
- Cyclones and other extreme storms
- Changing rainfall
- Population growth.

These issues/elements were then connected to other drivers that may impact the AOC system, such as rip currents, erosion, inundations, water quality and other drivers identified by the stakeholder group.

With drivers and impacts on the AOC system, including connections, clearly identified, the next step was to identify adaptive responses to these impacts. These may include coastal engineering works, relocation of facilities, and training and education of volunteers.

Figure 7 below represents a general conceptual model connecting factors, SLSA's AOC system and adaptive responses.

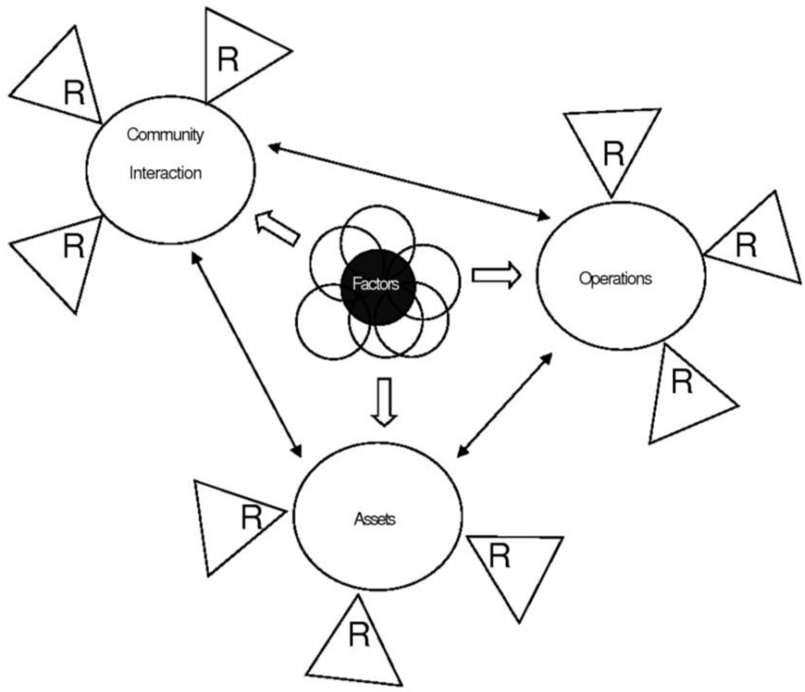


Figure 7: Conceptual model connecting driving forces (factors), impacts on the AOC and adaptive responses (R)

These elements were then recorded on VENSIM, a Systems Thinking software (Ventana Systems 2009). The exercise was conducted under the guidance of two facilitators. One stimulated the group to identify elements of and connections within the system; another recorded the conceptualisation using VENSIM.

2.3.5 First round of data analysis – Structural Analysis and System Dynamics modelling

The data from the first round of workshops were analysed (i) using MICMAC, a SD software, and (ii) transforming CLDs into stock and flow diagrams to complete SD simulation to explore the behaviour of variables over time.

2.3.5.1 Structural Analysis

The Structural Analysis used the MICMAC method (MICMAC n.d.). Structural Analysis is a tool designed to link up ideas. It allows stakeholders/researchers to describe a system using a matrix that links up all its constitutive elements. By studying these relations, analysts can underline the variables that are essential to the system's evolution. This has the advantage of stimulating reflection within a group and leading people to think about certain, sometimes counterintuitive, aspects of the system.

Structural Analysis is used for the qualitative study of extremely different systems, which have interrelated elements (variables/factors). The web of how these elements interact, that is, the system's configuration (structure), constitutes the key of its dynamics and remains quite permanent (Arcade et al. 1999). Structural Analysis uses three steps to bring this structure to light:

1. Organisation and inventory of variables: following the initial workshop. This stage, which is the least formal, is crucial for the rest of the process.
2. Description of relationships between variables: during this second stage, the point is to reconstitute and describe the web of relations, providing outcomes in terms of influence charts.
3. Identification of essential variables: this last stage consists of identifying essential variables and key factors to the system’s global dynamics.

This method relies on the use of MICMAC to collect and organise variables.

2.3.5.2 System Dynamics modelling

SD simulations enabled an exploration of the implications of different adaptive responses over a period of time. This was carried out using VENSIM, a software application. SD models enabled stakeholders to see how the system works and build a shared understanding of system modelling. The outcomes of the modelling process were presented to stakeholders during the second round of workshops, as a prelude to the exploration of adaptive capacity using BBNs. SD simulations included the following steps:

1. Model Development: SD models were formulated by translating MICMAC models into SD models (Cole et al. 2007). The modeller determined specific equations and functions needed to explain relationships between variables. SD stock and flow diagram conventions were used to exhibit system structure (Figure 8). Stocks (X) are the system state variables, illustrated by boxes. The dynamics of a system are defined by its state variables; the flow in a system represents the rates of change, and is

represented by pipes (dX). Auxiliary variables (Y) are used to break the flow equations into manageable segments, with a clear meaning (Fiddaman 1997).

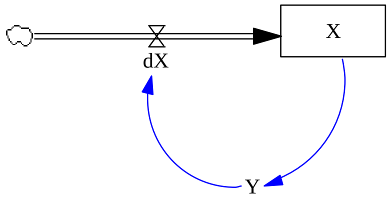


Figure 8:. Stock and flow diagramming convention

Source: Adapted from Fiddaman 1997

2. Sensitivity testing: the results were examined to determine whether the model works effectively in simulating the system behaviour over time. Sensitivity testing allowed us to (i) explore how the models respond to small changes in input values, parameter values or other assumptions, (ii) test the robustness of the model structures and assumptions by identifying biases in model calculations, and (iii) provide information about whether the model needs to be revised.
3. Interpretation of results: once the previous steps were completed, the results were interpreted to provide interim conclusions and ideas to be fed into the second round of workshops.

2.3.6 Second round of workshops – Bayesian modelling

BBN models were developed during the second series of stakeholder workshops, in October/November 2012. The workshops focused on the critical elements that emerged during the initial workshops and the following analysis of data. BBNs were constructed around adaptive responses to identify a set of adaptive capacity determinants. The development of the models was undertaken using Netica software (Norsys 2012), a dedicated BBN platform. The process was undertaken in four stages:

Pre-development information: The stakeholders were given an overview of the framework that will be used to develop the BBNs, including formal definitions of common BBN terms ('variables', 'states', 'causality', 'linkages') and specification of the key methodological requirements for developing the model structure and discretisation of variable states. Simple examples unrelated to the project were provided. This helped stakeholders understand the BBN model development process (Richards et al. 2012).

BBN structure development: The stakeholders were asked to identify up to three variables (adaptive capacity determinants) that influence the adaptation response variable (critical element) – this represents the first level of the BBN structure. Further hierarchical layers were added to the BBN using the same process until a network of variables was created. Depending on the time availability during the workshop, these Bayesian networks were developed to 3–4 hierarchical levels. The participants then discretised (described) all variables within the BBN using qualitative descriptors. Guidance was given to the stakeholders regarding the number of discretised states associated with each hierarchical level so that large and intractable CPTs were avoided during the latter stage of the BBN development (Marcot et al. 2001).

Conditional Probability Tables (CPTs): The developed BBN structure was then parameterised by the stakeholders by populating the associated CPTs for each variable that is influenced by other variables. CPTs quantify the strength of causality between 'parent' and 'child' nodes. These CPTs were populated through a combination

of one-on-one meetings during the workshop. Contrasting the development of the BBN structure (based on the collective belief of workshop participants), the CPTs were populated based on individual stakeholder beliefs. This allows individual probabilities to be compared through the use of auxiliary 'expert' variables in the BBN (Kjærulff and Madsen 2008). These auxiliary variables were specified for every child variable within the BBN structure with the contribution of each stakeholder's CPT weighted equally.

Narrative capture: Discussions between participants throughout the workshops and comments by individuals during the CPT populating process were recorded to give additional context to the modelling process. The narrative that accompanies model development has been shown to provide important contextual information (Richards et al. 2012).

2.3.7 Final round of data analysis – sensitivity testing to identify adaptive capacity determinants and pathways

A final sensitivity analysis was undertaken on each BBN using Netica. This helped identify the inputs that most affect the output and is an important process in model testing, to understand the influential pathways through the developed BBNs (Howes et al. 2010; Marcot et al. 2001) and, in the context of this study, identifying important determinants of adaptive capacity.

3. RESULTS

Results reported here include those from (i) the stakeholder identification and engagement process, including information from the survey, (ii) the system conceptualisation and Structural Analysis, (iii) the SD simulations, and (iv) the BBN modelling.

3.1 Stakeholder identification and engagement

The stakeholder identification and engagement process encompassed the identification of the project champion, stakeholder identification for workshops and the preparation of an additional survey to explore opinions on climate change and social networks.

3.1.1 Project champion identification

The identification of the project champion was done in cooperation with SLSA. We identified three project champions, one in each case study area:

1. Mr David Field, Cudgen Headland SLSC
2. Mr Michael Sullivan, CEO, Currumbin SLSC
3. Mr Graham Berry, President, Ulverstone SLSC.

In addition, Shauna Sherker, SLSA Research Manager, acted as project champion for SLSA.

3.1.2 Stakeholder identification

Project champions identified 44 stakeholders, including both club members and members of the community or government organisations, distributed as follows (Table 3):

Table 3: Stakeholders involved in the workshops at different locations

	CLUB/SLSA MEMBERS	LOCAL GOVERNMENT	COMMUNITY
Cudgen Headland SLSC	4	4	5
Currumbin SLSC	7	3	3
Ulverstone SLSC	4	1	3
SLSA	9	/	/

3.1.3 Survey outputs

3.1.3.1 Attitudes and preferences of SLSC stakeholders for climate change adaptation

The survey was distributed to participants in the ABFlags research project at both the Cudgen Headland and Ulverstone SLSCs. The participants included a mix of club members and club stakeholders such as government employees and community group members. The survey was available for completion online or in hard copy at the Round 2 workshops. There were 19 total responses received, with 8 from Cudgen Headland and 11 from Ulverstone.

Respondents were asked to provide demographic data, including their membership of a SLSC. Table 4 provides details of the respondents, the club that they participated in the ABFlags research for and if they were members or non-members of an SLSC.

Ulverstone had a larger proportion of non-members involved in the planning exercise than Cudgen Headland, which only had one non-member.

Table 4: Respondents to the survey

	TOTAL	ULVERSTONE	CUDGEN HEADLAND
Club members	13	6	7
Non members	6	5	1
Total	19	11	8

Respondents were asked: 'From what you know about climate change, which of the following statements comes closest to your opinion?' They were provided with a number of options and their responses are provided in Figure 9 below, broken down by club. At both clubs at least 50% of respondents agreed that climate change is an issue requiring immediate action: there is a greater percentage (80%) at Ulverstone than at Cudgen Headland (50%). In addition, no response indicated that no action was necessary or that they had no opinion (Figure 9).

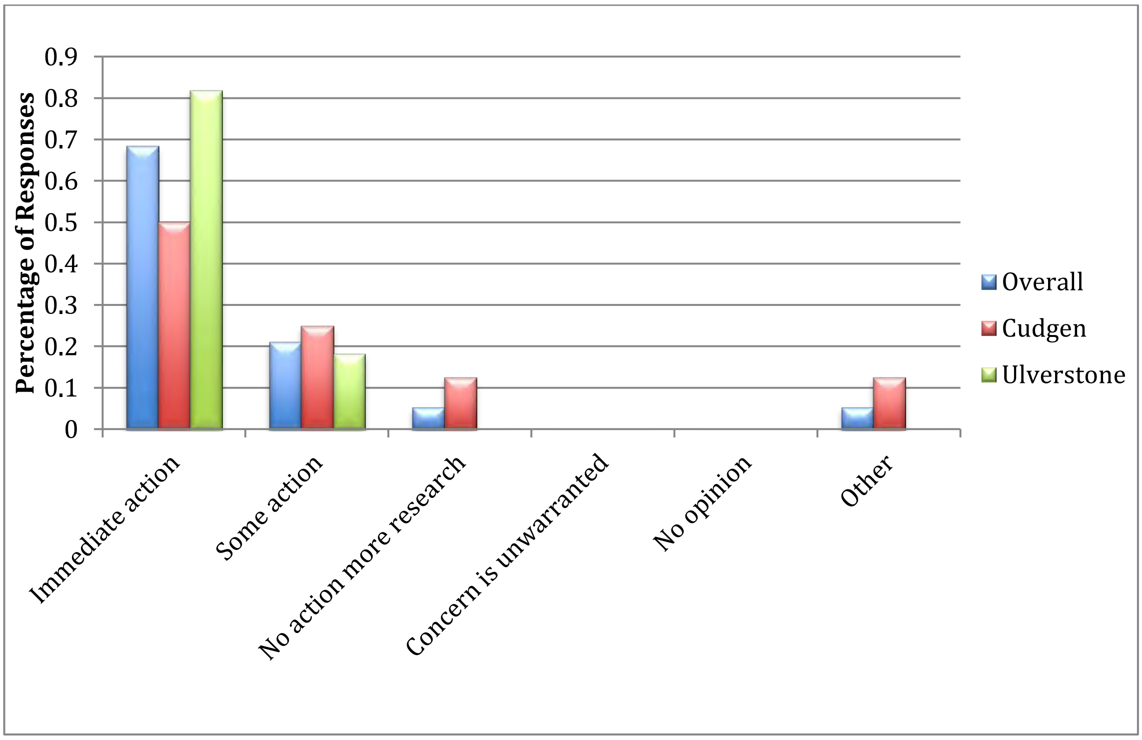


Figure 9: Opinions about climate change

Respondents were asked, 'If sea levels were to rise and/or erosion and flooding risks increase, which of the following statements best represents your views?' Figure 10 below provides both the statements and the percentage of responses for each, broken down by club. The lowest number of responses for Ulverstone was for engineered structures, with the majority preferring retreat or some sort of accommodating approach. This differed from Cudgen Headland, where responses were balanced across the defend, retreat and accommodate options. This may reflect the difference of experience at the clubs, with Cudgen Headland recently having a seawall constructed to address erosion, whereas Ulverstone has no experience with coastal protection.

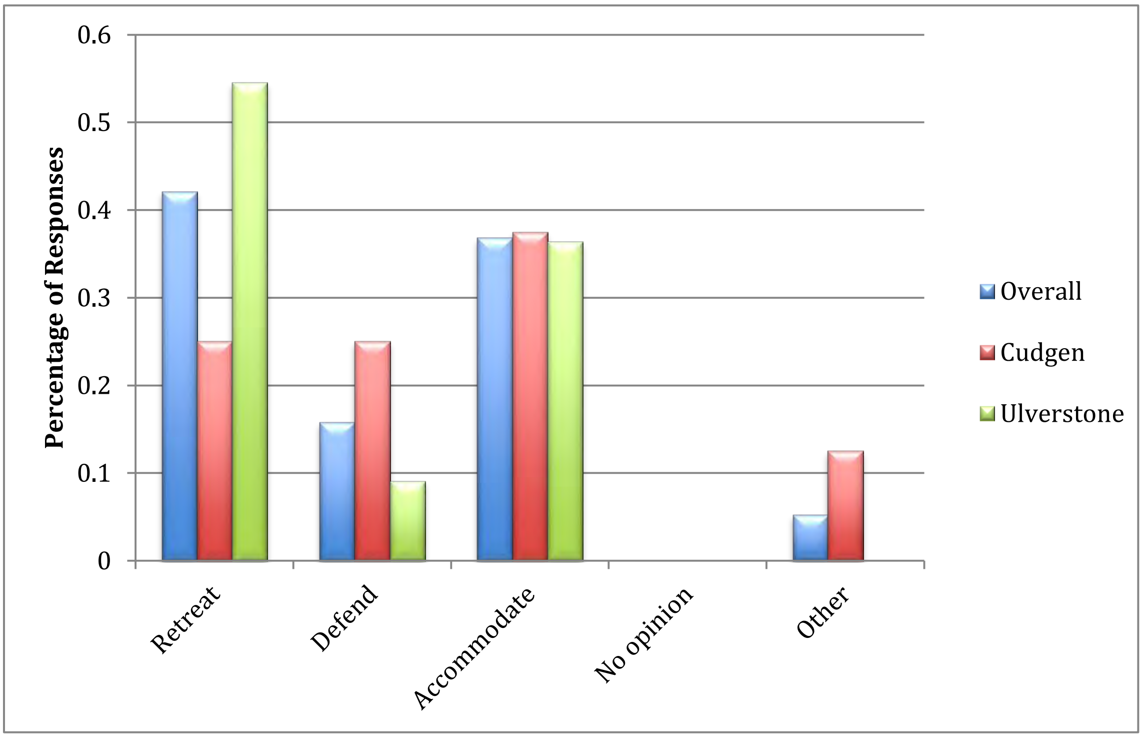


Figure 10: Preferences for adaptation to climate change

Note: Retreat = move infrastructure and housing to safer locations protected from rising waters; Protect = use engineered structures to protect infrastructure and housing from rising waters; Accommodate = use a combination of design, new materials and change behaviour to accommodate rising waters.

Respondents were asked to rate a list of issues for beach and foreshore recreation and safety in terms of their priority. The scale was from 1 to 4, where 1 was high priority and 4 was not an issue. Table 5 below displays an average across all responses for priority rating. The issues are shown in order of priority, with the first being the highest priority and the last the lowest priority. The highest priority was physical exposure to hazards; while the lowest was increased population, the average was still 2.63, putting it above low priority.

Table 5: Main issues for beach and foreshore recreation and safety

PRIORITY LEVEL (AVERAGE)	ISSUE
1.37	Physical exposure (sea level rise, storm surge, shoreline loss, erosion)
1.68	Impact on existing public infrastructure
1.72	Potential development in vulnerable locations
1.74	Loss of foreshores and recreation areas
1.79	Capacity of emergency response systems
2.06	Legal liability for governments in planning decisions
2.11	Impact on existing private homes
2.16	Lifestyle impacts (natural amenity, climate)
2.26	Economic impacts on tourism sector

2.63	Increased population

3.1.4 Social networks

The following tables (Tables 6 and 7) report the results of a simplified analysis carried out to better understand community connections and relevance of stakeholders for Cudgen Headland SLSC and Ulverstone SLSC. In both cases, the analysis was based on the number of connections identified by stakeholders using a scale from 0 to 3 where 0 indicates no connection and 3 indicates strong ties. Stakeholders' personal data (name) were not reported for privacy reasons. Stakeholders scoring the highest number of connections should be considered as those with the highest influence in the community.

Table 6: Results from the analysis of community networks for Cudgen Headland SLSC stakeholders

STAKEHOLDER ID	ORGANISATION	FINGAL ROVERS SLSC	KINGSCLIFF CHAMBER OF COMMERCE	TWEED SHIRE	KINGSCLIFF BOARDRIDERS CLUB	KINGSCLIFF RATEPAYERS	SALT SLSC	TWEED HEADS CHAMBER OF COMMERCE	NSW PUBLIC WORKS	NSW DEPARTMENT OF LANDS	TOTAL
1	Kingscliff Chamber of Commerce	3	3	0	0	3	3	3	0	0	15
6	Kingscliff Ratepayers	0	0	3	3	3	0	0	2	1	12
8	Tweed Shire Council	0	2	3	0	2	0	0	0	0	7
2	Cudgen Headland SLSC	0	0	3	0	3	0	0	0	0	6
5	Cudgen Headland SLSC	0	0	3	3	0	0	0	0	0	6
4	Tweed Shire Council	0	0	3	0	0	0	0	0	0	3
3	Cudgen Headland SLSC	0	0	0	0	0	0	0	0	0	0
7	Kingscliff Resident	0	0	0	0	0	0	0	0	0	0

Table 7: Results from the analysis of community networks for Ulverstone SLSC stakeholders

STAKEHOLDER ID	STAKEHOLDER ORGANISATION	LEVEN YACHT CLUB	TB COAST CARE	NW COAST CARE	BURNIE SLSC	RUBICON LANDCARE	CENTRAL COAST COUNCIL	CRADLE COAST NRM	TASMANIAN GOVERNMENT	CROWN LANDS	FEDERAL GOVERNMENT	NATIONAL PARKS	SPORTS CLUBS	TOTAL
6	State Government	3	0	0	0	3	3	0	3	0	2	0	0	14
1	Coast Care	0	3	3	0	0	3	0	1	0	0	0	0	10
10	Coast Care	0	3	0	0	0	3	2	0	0	0	0	2	10
8	Primary School	0	2		0	0	3	0	0	1	0	1	0	7
2	Ulverstone SLSC	0	0	0	3	0	0	0	0	0	0	0	0	3
4	Ulverstone SLSC	0	0	0	0	0	3	0	0	0	0	0	0	3
5	Ulverstone SLSC	0	3	0	0	0	0	0	0	0	0	0	0	3
9	Ulverstone SLSC	0	3	0	0	0	0	0	0	0	0	0	0	3
3	Ulverstone SLSC	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Ulverstone SLSC	0	0	0	0	0	0	0	0	0	0	0	0	0

3.2 System conceptualisation and Structural Analysis

3.2.1 Inventory and organisation of variables

During the workshops, triggering questions were used to identify variables (see section 2.3.4). Variables were captured using VENSIM and classified as *Drivers*, *Assets*, *Operations*, or *Community* interactions. These were then used to trigger the identification of *Adaptive responses*. The limited amount of time and the complexity of the system did not allow full appreciation of the connections between variables, which were omitted, giving priority to the construction of a cloud of variables based on the results of group brainstorming for approximately 45 minutes. The cloud of variables was then organised in tables prior to MICMAC analysis of relationships, influence and dependence. The figures below (Figure 11 to 14) and tables (Tables 8 to 12) show respectively the cloud of relationships and the variables used in MICMAC.

3.2.1.1 Cudgen Headland SLSC

Figure 11: Variables identified at Cudgen Headland SLSC (A=Assets, O=Operations, AO=Adaptation Options)

Table 8: Variables used for the MICMAC Structural Analysis, Cudgen Headland SLSC

N°	LONG LABEL	SHORT LABEL	DESCRIPTION	THEME
1	Beach	BEACH		Asset
2	Coastal vegetation	VEG	This includes the banksias, Norfolk pines, pandanus	Asset
3	Boat ramp	BTRMP	Boat ramp is used for beach access	Asset
4	Boatsheds	BTSHD	Sheds are used to store boats and other equipment	Asset
5	Bowling park	BWLPRK	The bowlo is an important asset for the broader community	Asset
6	Car park	CARPARK	The car park of the club	Asset
7	Caravan park	CRVPARK	The caravan park is being eroded by extreme storms	Asset
8	Clubhouse	CLUB	The clubhouse building	Asset
9	Coastal dunes	DUNES	Coastal dunes are part of the shoreline	Asset
10	Membership	MEMB	Membership is important to the club	Asset
11	Public open space	OPSPACE		Asset
12	Seawall	SEWAL	The seawall protecting the shore	Asset
13	Surfing waves	WAVES	Waves are important for the surfers	Asset
14	Vehicles	VEHIC	Vehicles of the club	Asset
15	Visual amenity	LANDSCP	Visual amenity from the clubhouse	
16	Offshore reefs	REEF	Offshore reefs control waves and are an asset for fishing	Asset
17	Board riders	SURFERS	Surfers	Community
18	Emergency services	EMSERV	Emergency services operate in collaboration with the club	Community
19	RSL	RSL	Retiree from service league	Community
20	Population growth	POPGRWTH	Population is expected to grow in the near future	Driver of change
21	Extreme storms	EXTRM	Mainly east coast lows and cyclones	Driver of change
22	Wave climate	WAVCL	Wave climate variability and change	Driver of change
23	ANZAC Day	ANZAC	Source of revenue	Operations
24	Beach safety	SAFE	Main occupation of club's volunteers	Operations
25	Surf carnival	CARNV	Carnivals are occasional surf life saving sport events	Operations
26	Training	TRAIN	Training of club members	Operations
27	Sport training	SPTRAIN	Club members surf life saving sports training	Operations
28	Tourists	TOURS	Tourists coming to Kingscliff in summer	Asset
29	Local community	COMM	Local community living in the area	Community

3.2.1.2 Currumbin SLSC

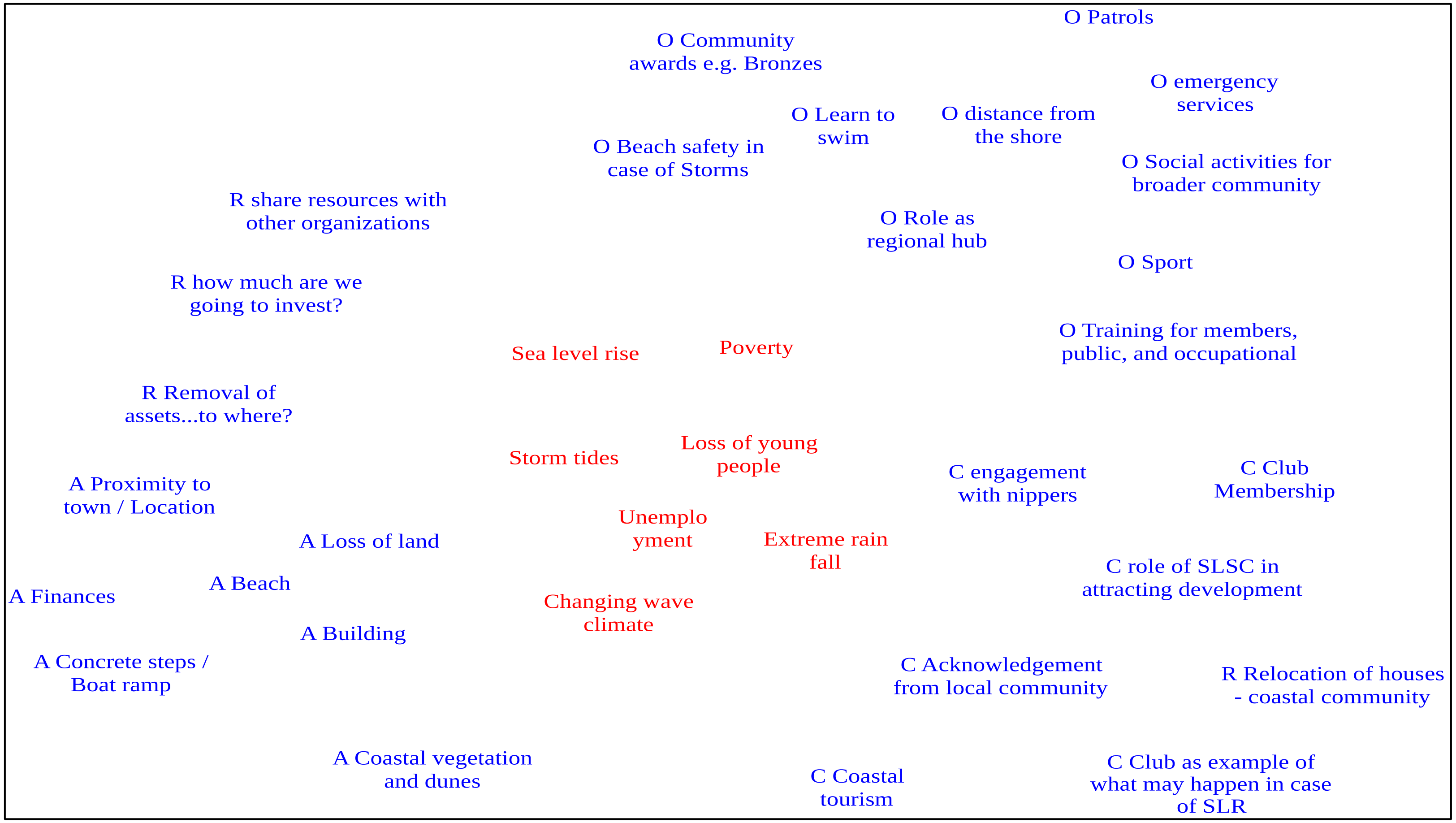


Figure 12: Variables identified at Currumbin SLSC (A=Assets, O=Operations, AO=Adaptation Options)

Table 9: Variables used for the MICMAC Structural Analysis, Currumbin SLSC

N°	LONG LABEL	SHORT LABEL	DESCRIPTION	THEME
1	Accessibility	ACCES	Accessibility to the club	Asset
2	Beach	BEACH	The beach is an asset to the club	Asset
3	Erosion	EROSION	Beach erosion can affect the club's assets and operations	Driver of change
4	Beach Safety	SAFETY	Beach safety is the main operation of the club	Operations
5	Boat and equipment shed	SHED	The shed is where SLSC boats and other equipment is stored	Asset
6	Boat ramp	RAMP	The boat ramp is used to move boats	Asset
7	Building	BUILD	The whole SLSC building	Asset
8	Car park	CARPARK	The car park provides access to the club and the beach	Asset
9	Competition equipment	COMPEQ	The equipment used for competition purposes	Asset
10	Creek	CREEK	The Currumbin creek	Asset
11	Cyclones	CYCLON	Cyclones can impact or cross the Gold Coast shores	Driver of change
12	Sea level rise	SLR	Sea level rise is expected to impact shores in the future	Driver of change
13	Economic trends	ECON	Changes in the economy may impact the socio-economic fabric of the region and the local community	Driver of change
14	Dunes	DUNE	Dunes are an important natural element for coastal protection and biodiversity	Asset
15	Employment	EMPLOY	SLSC provides employment to a number of people	Operations
16	Entertainment	ENTERT	SLSC is a venue for entertainment	Operations
17	Fitness	FITNS	SLSC is a place for fitness and exercise	Operations
18	Membership	MEMB	Membership is one of the main operations and is the core of the club's life	Operations
19	Nippers training facility	NIPFAC	The training facility for children (nippers) is located across the road	Asset
20	Patrols	PTRL	Patrols are carried out by club's members	Operations
21	Rock	ROCK	The rock on which the club sits is an asset for protection and landscape	Asset
22	Rolling doors	ROLL	Rolling doors are opened during storm tide inundations	Asset
23	Storms	STRMS	Storms are extreme events with waves and winds stronger than average conditions	Driver of change
24	Surfing wavers	WAVE	Surfing waves size and quality is an asset to beach use	Asset
25	Swimming sport	SWSP	Swimming as a sport activity	Operations
26	Tourism	TOUR	Tourism can drive the economy of the area	Driver of change
27	Surf life saving training	SLST	One of the main activities of the club is training for club members	Adaptive Response
28	View from the club	VIEW	The view from the club is one of the main assets, in practice a source of revenue	Asset
29	Weddings	WEDD	Weddings are a year-round event for the club	Operations

N°	LONG LABEL	SHORT LABEL	DESCRIPTION	THEME
30	Yearly events (Australia Day, ANZAC Day, etc.)	EVNT	Yearly events are relevant to the economy of the club	Operations
31	Life saving equipment	EQUIP	Improve life saving equipment to new conditions	Adaptive Response
32	Accommodate extreme water levels	ACCOM	Accommodate extreme water levels by changing design standards and upgrading infrastructure	Adaptive Response

3.2.1.3 Ulverstone SLSC

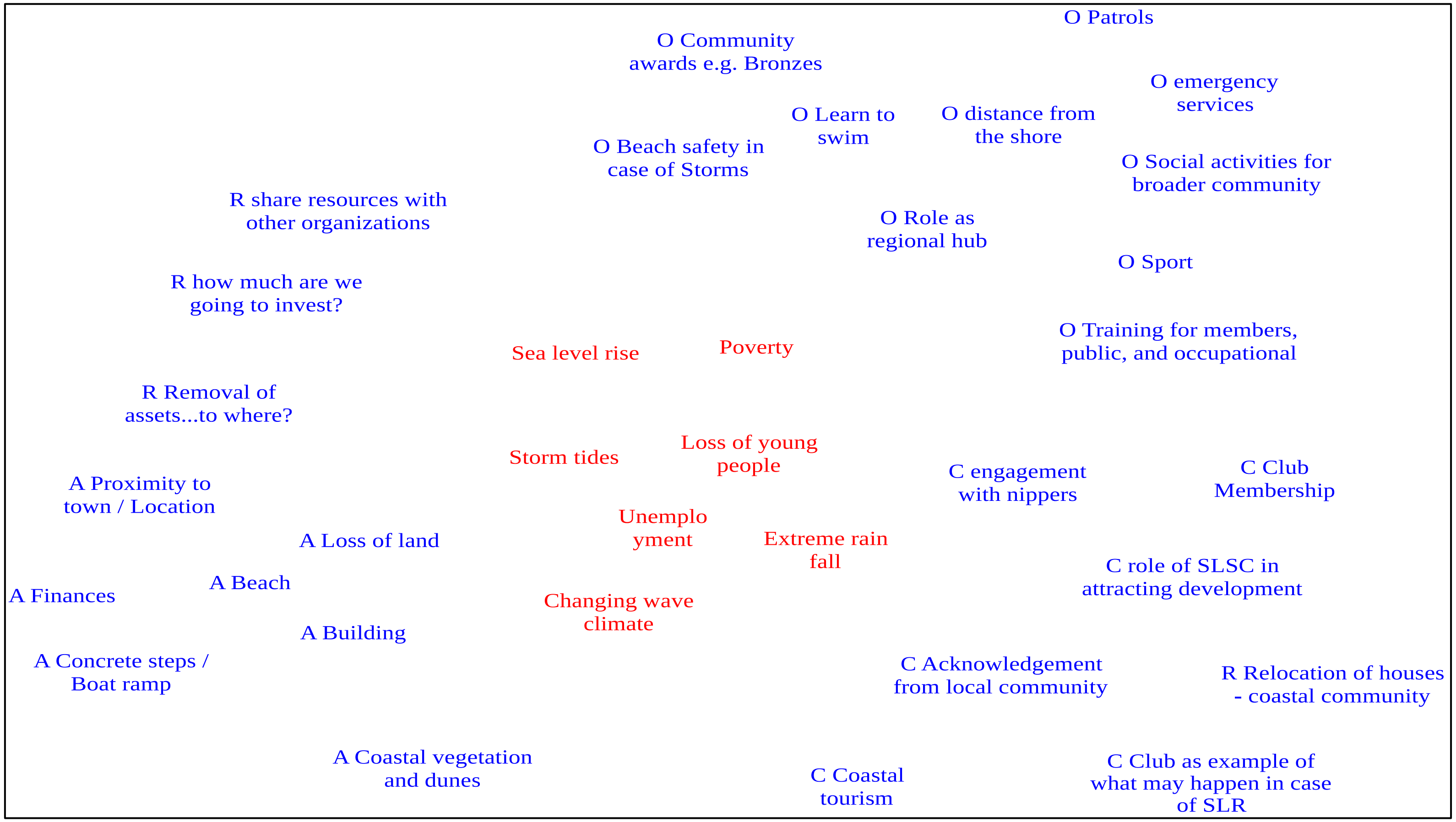


Figure 13: Variables identified at Ulverstone SLSC (A=Assets, O=Operations, AO=Adaptation Options)

Table 10: Variables used for the MICMAC Structural Analysis, Ulverstone SLSC

N°	LONG LABEL	SHORT LABEL	DESCRIPTION	THEME
1	Beach	BEACH	The beach of Ulverstone is an asset to the community and the club	Asset
2	Clubhouse	CLBHS	The main asset to manage is the clubhouse	Asset
3	Coastal dunes system	DUNES	Coastal dunes, including vegetation	Asset
4	Concrete steps and boat ramp	STPRMP	Concrete steps and boat ramp of the clubhouse	Asset
5	Land	LAND	Land belonging to the club	Asset
6	Location	LOCAT	The location of the clubhouse is important, as it is close to town	Asset
7	Acknowledgement	ACKNOW	Acknowledgement from local community	Community
8	Membership	MEMB	Club membership	Community
9	Coastal tourism	TOUR	Coastal tourism contributes to the community	Community
10	Nippers	NIPRS	Engagement with children (nippers)	Community
11	Changing storms	STRMS	Changing storms, including storm tides and wave climate	Driver of change
12	Unemployment	UNEMP	Unemployment within the community	Driver of change
13	Beach safety	SAFE	Beach safety, especially in case of storms	Operations
14	Community awards	AWARDS	Community awards, e.g. bronze medallions	Operations
15	Emergency services	EMERG	Contribute to emergency operations	Operations
16	Swimming	SWIM	Swimming school	Operations
17	Patrols	PATROL	Patrols of surf life saving volunteers	Operations
18	Social activities	SOCIAL	Social activities within the club	Operations
19	Sport	SPORT	Surf life saving sport in the club	Operations
20	Training	TRAIN	Training for members, public and occupational	Adaptive Response
21	Equipment	EQUIP	Upgrade equipment to cope with climate change and extremes	Adaptive Response
22	Defend	DEFEND	Defend the current position of the clubhouse with engineering solutions	Adaptive Response
23	Retreat	RETREAT	Retreat the clubhouse to safer grounds	Adaptive Response

3.2.1.4 *Surf Life Saving Australia*

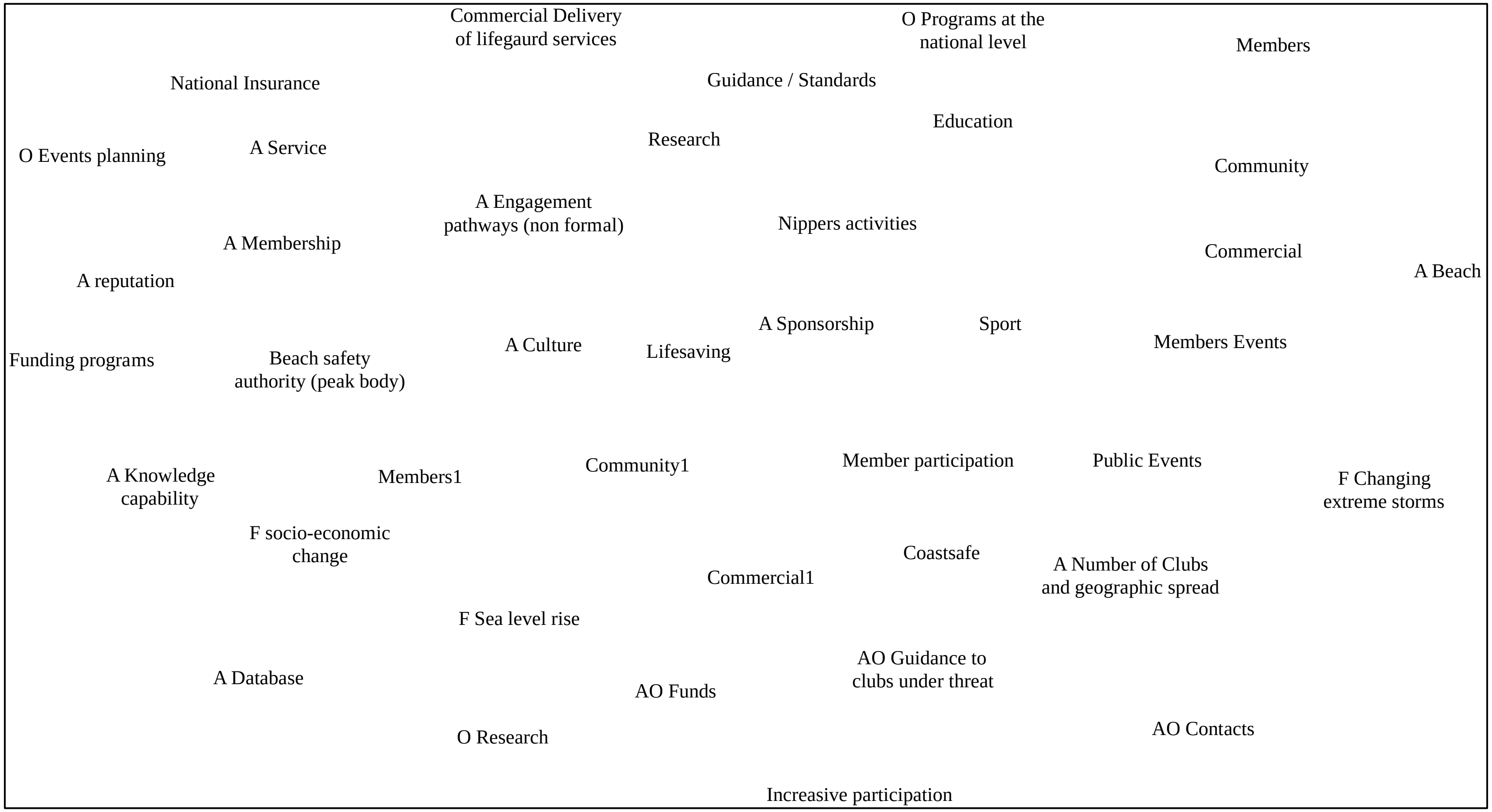


Figure 14: Variables identified at SLSA (A=Assets, O=Operations, AO=Adaptation Options)

Table 11: Variables used for the MICMAC Structural Analysis, SLSA

N°	LONG LABEL	SHORT LABEL	DESCRIPTION	THEME
1	National Insurance	INSURANCE	A national insurance scheme for clubs at risk	Adaptive Response
2	Adaptation guidance	GUIDANCE	Guidance for clubs under threat from sea level rise and extreme storms	Adaptive Response
3	Funding	FUNDS	Funding to SLSA and clubs from a range of sources	Adaptive Response
4	CoastSafe	COASTSAFE	Australian CoastSafe is the strategic and intelligence beach safety unit of SLSA, developed to gather data on all beaches around Australia and establish a framework to deliver a safer aquatic environment	Asset
5	Sponsors and partners	SPONSORS	Sponsors are the main source of income for SLSA	Asset
6	Service	SERVICE	SLSA offers service to clubs and the community	Asset
7	Reputation	REPUT	Reputation is an asset of SLSA	Asset
8	Clubs	CLUBS	Number of clubs and geographical spread	Asset
9	Membership	MEMBERS	Membership is an asset of SLSA	Asset
10	Knowledge capability	KNOWLEDGE	Knowledge capability	Asset
11	Databases	DATABASE	Databases of information	Asset
12	Culture	CULTURE	The culture of SLSA in Australia and beyond	Asset
13	Socio-economic change	SOCECONOM	Socio-economic change	Driver of change
14	Sea level rise	SLR	Sea level rise	Driver of change
15	Extreme storms	EXTREME	Extreme storms, erosion and floods	Driver of change
16	Sport	SPORT	Surf life saving as a sport	Operations
17	Research	RESEARCH	Research on water safety and other issues	Operations
18	Public events	EVENTS	Public events	Operations
19	Education	EDUCATION	Education programs	Operations
20	Professional lifeguard services	LIFEGUARD	Professional lifeguard services	Operations
21	Commercial operations	COMMERC	Commercial operations	Operations
22	Disaster response support	DISASTER	Provide direct support to clubs under threat or damaged by storms and cyclones	Adaptive Response
23	Mainstream climate change	MAINSTREAM	Mainstream climate change into operational procedures to facilitate integrated management of climate risks within SLSA operations	Adaptive Response
24	Monitoring Climatic Risk	MONRSK	Establish mechanisms to monitor the impacts of climate change and other risks across the organisation (i.e. a climate risk reporting framework)	Adaptive Response

3.2.2 *Description of relationships between variables*

3.2.2.1 Cudgen Headland SLSC

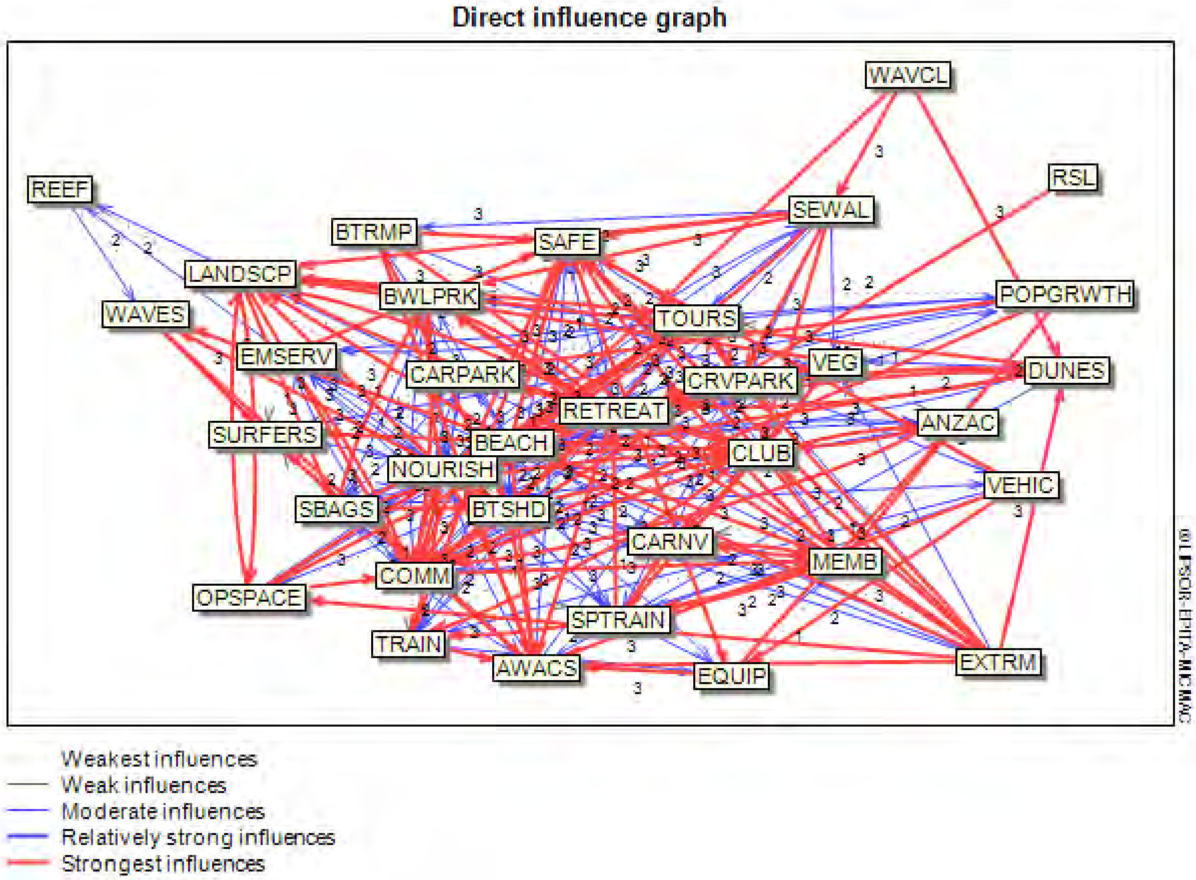


Figure 15: Direct influence conceptual model, Cudgen Headland SLSC

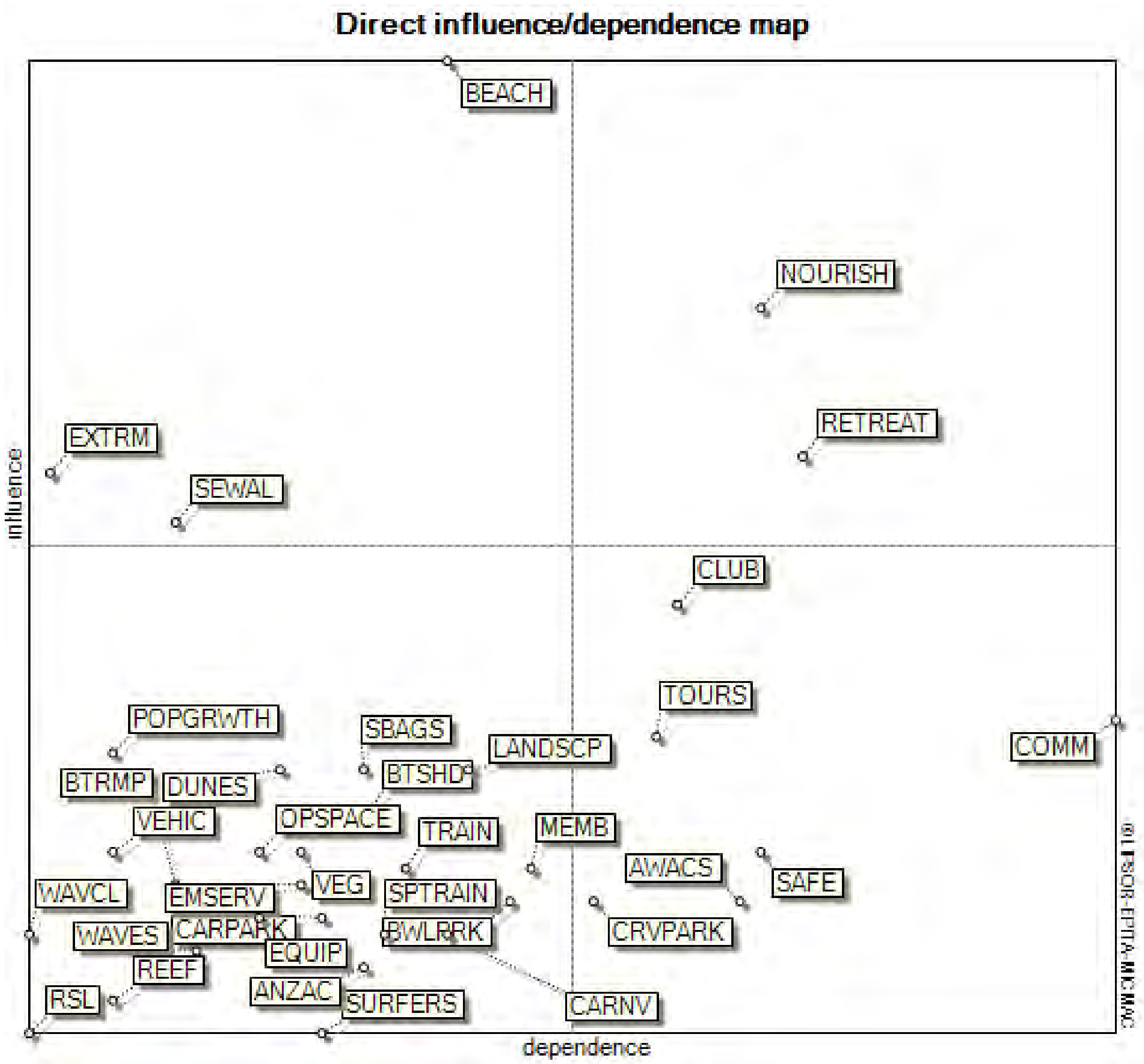


Figure 16: Direct influence/dependence map, Cudgen Headland SLSC

3.2.2.2 *Currumbin SLSC*

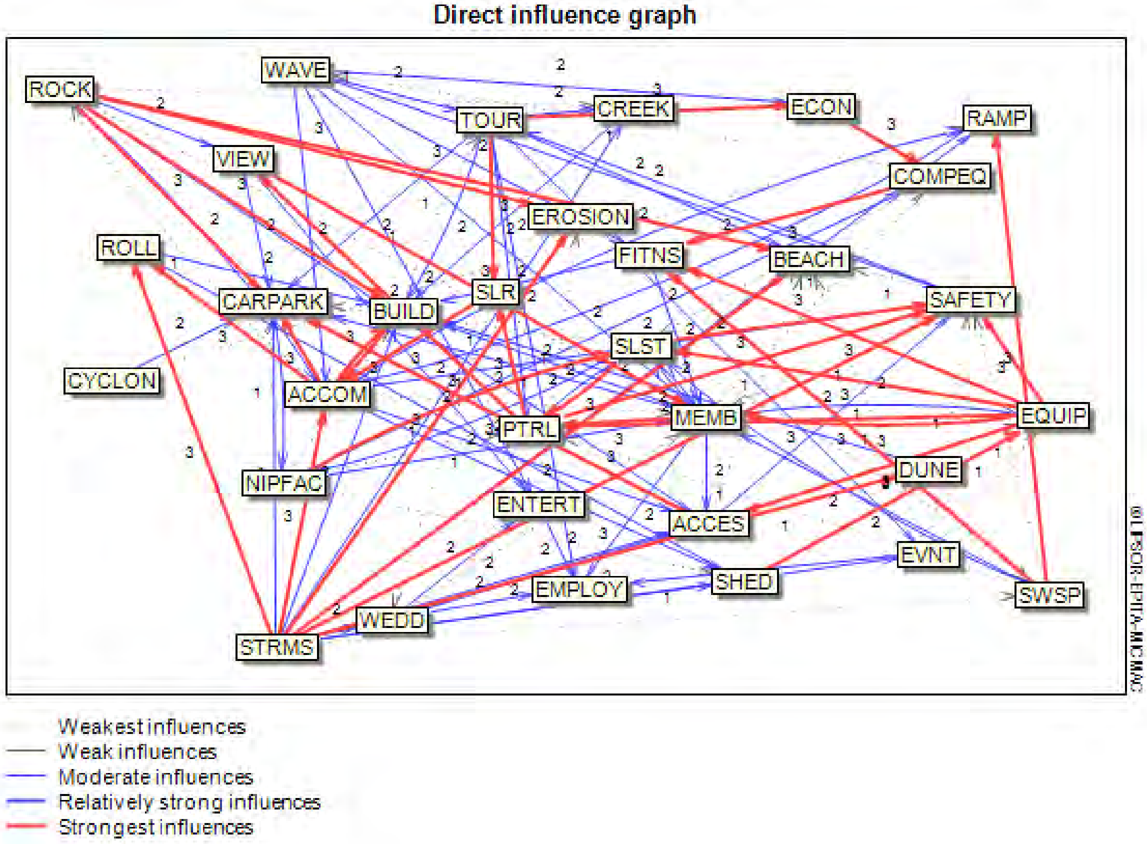


Figure 17: Direct influence conceptual model, Currumbin SLSC

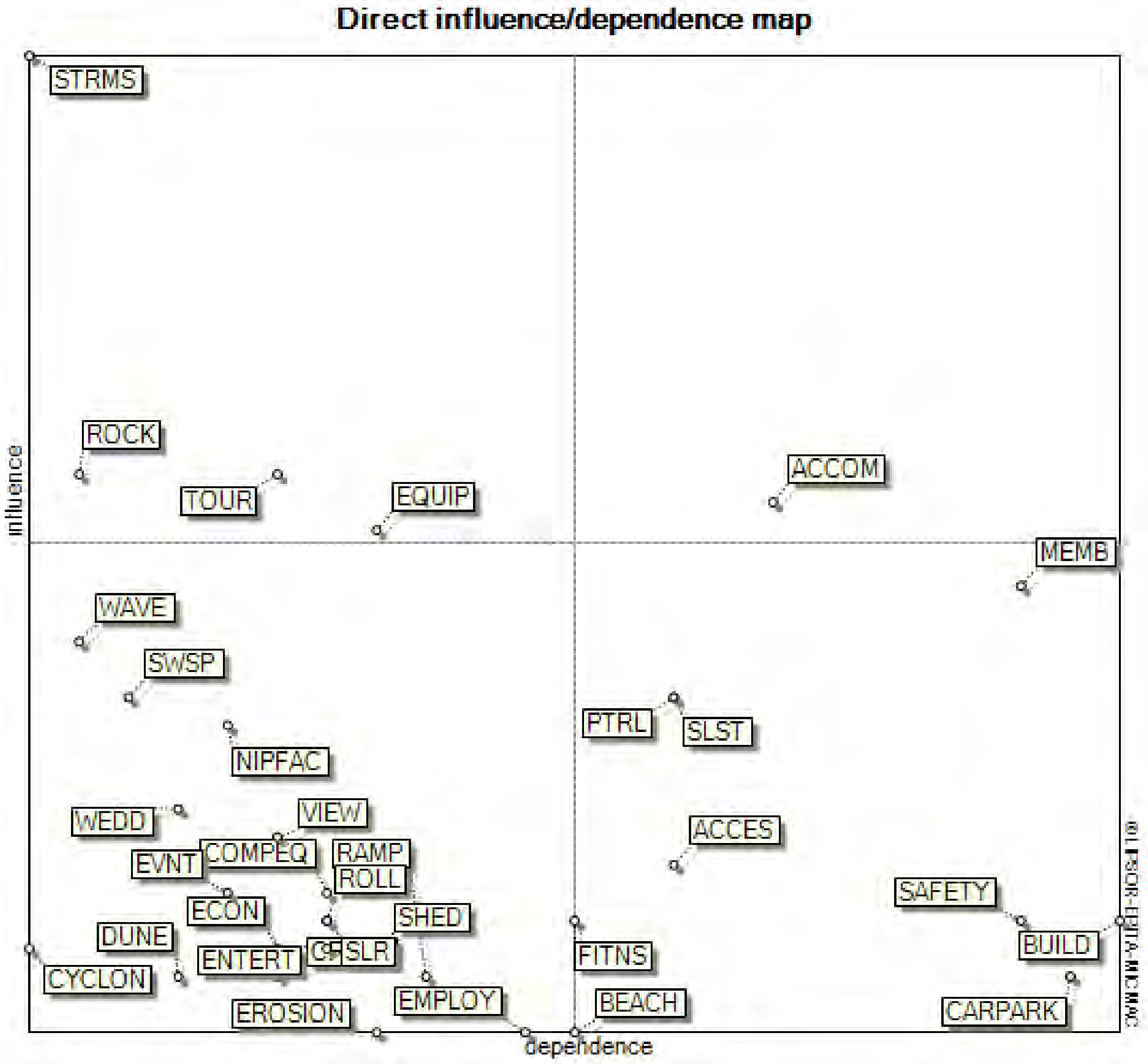


Figure 18: Direct influence/dependence map, Currumbin SLSC

3.2.2.3 Ulverstone SLSC

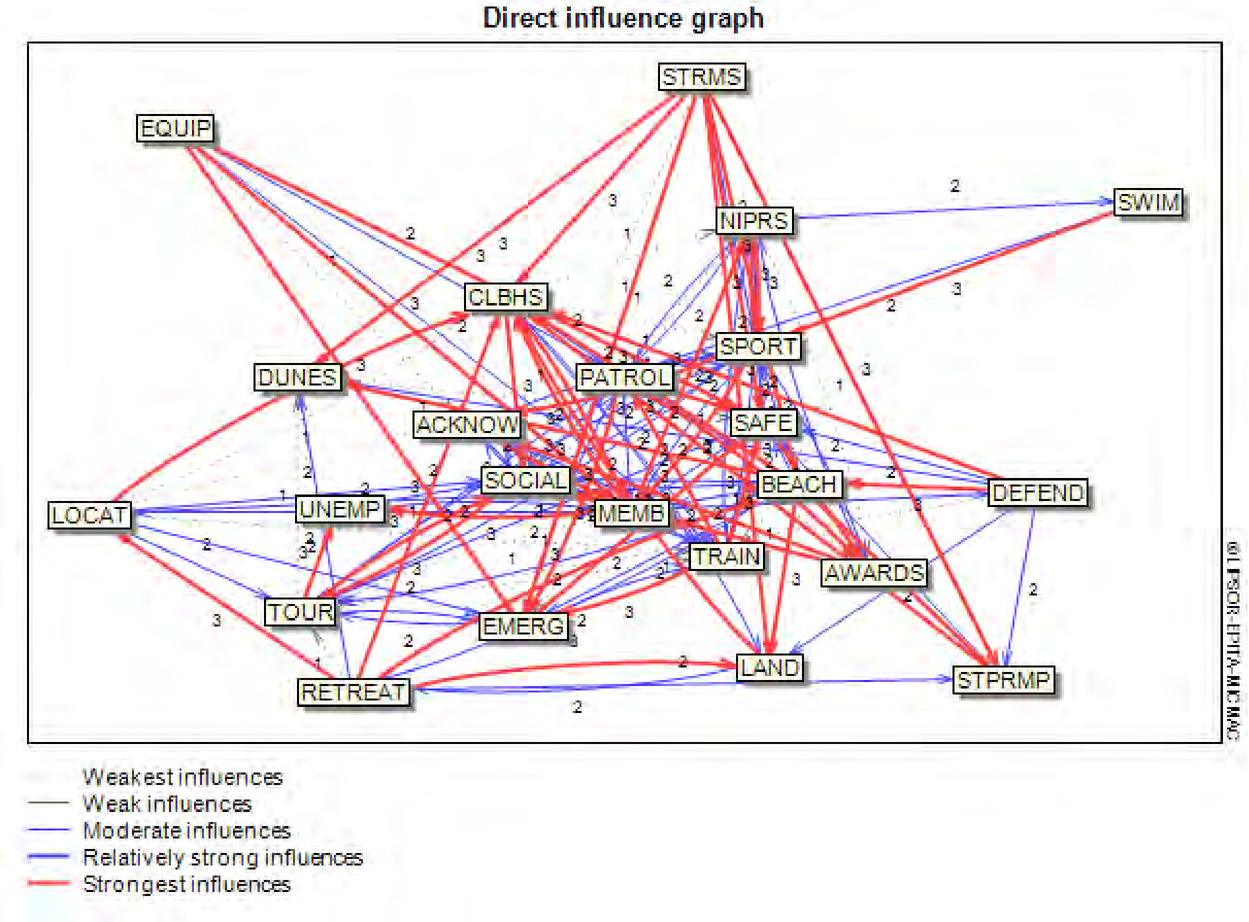


Figure 19: Direct influence conceptual model, Ulverstone SLSC

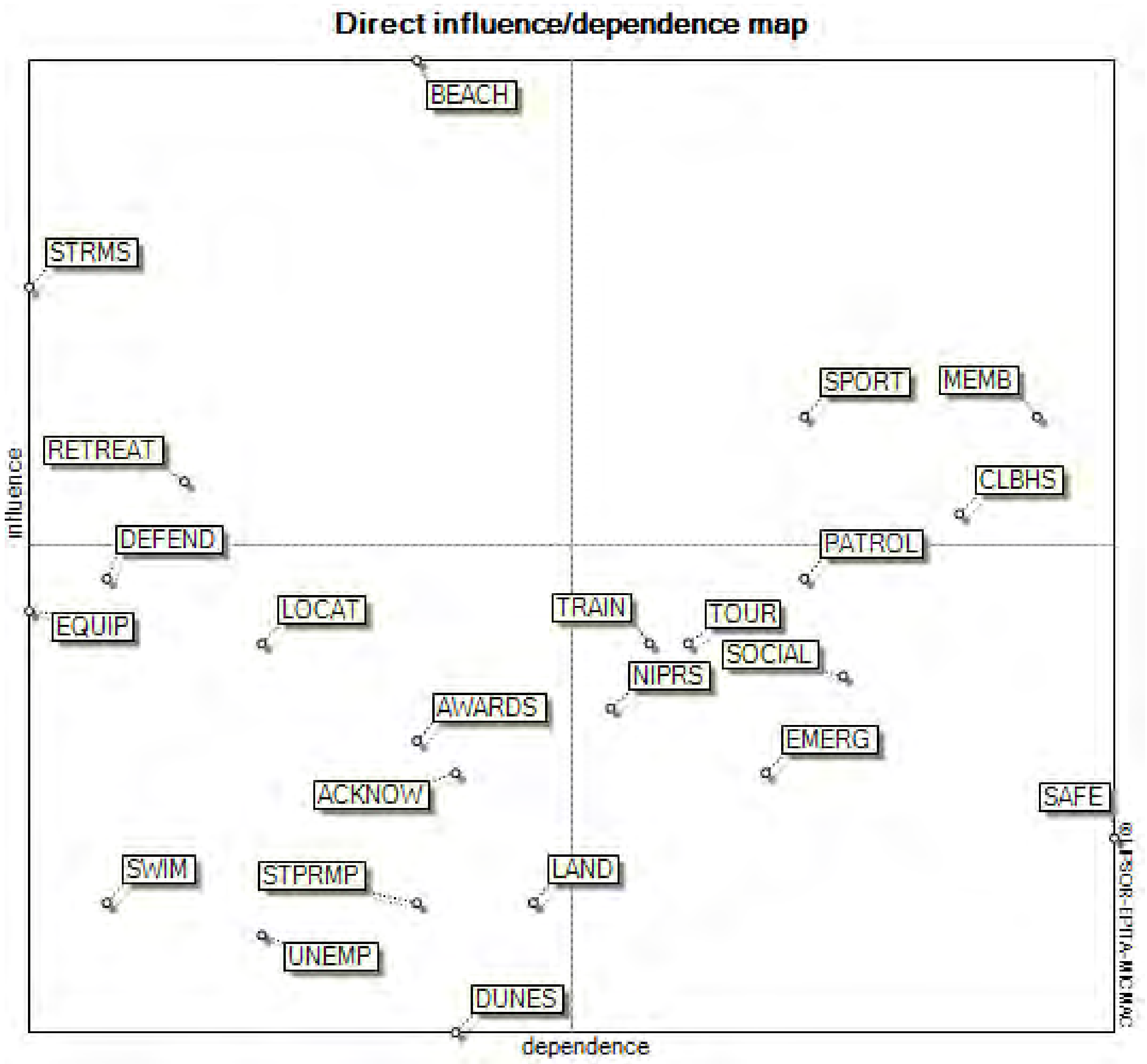


Figure 20: Direct influence/dependence map, Ulverstone SLSC

3.2.2.4 SLSA

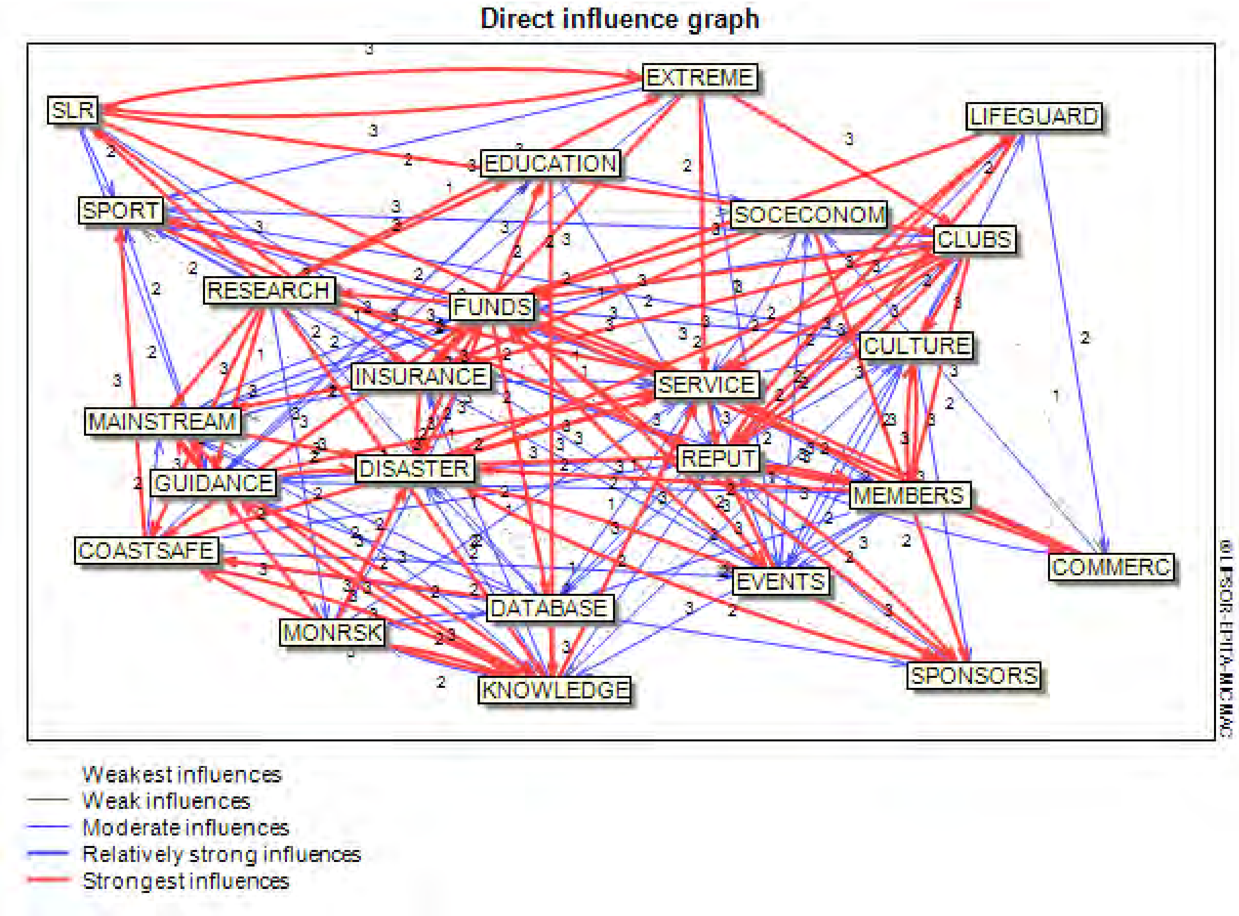


Figure 21: Direct influence conceptual model, SLSA

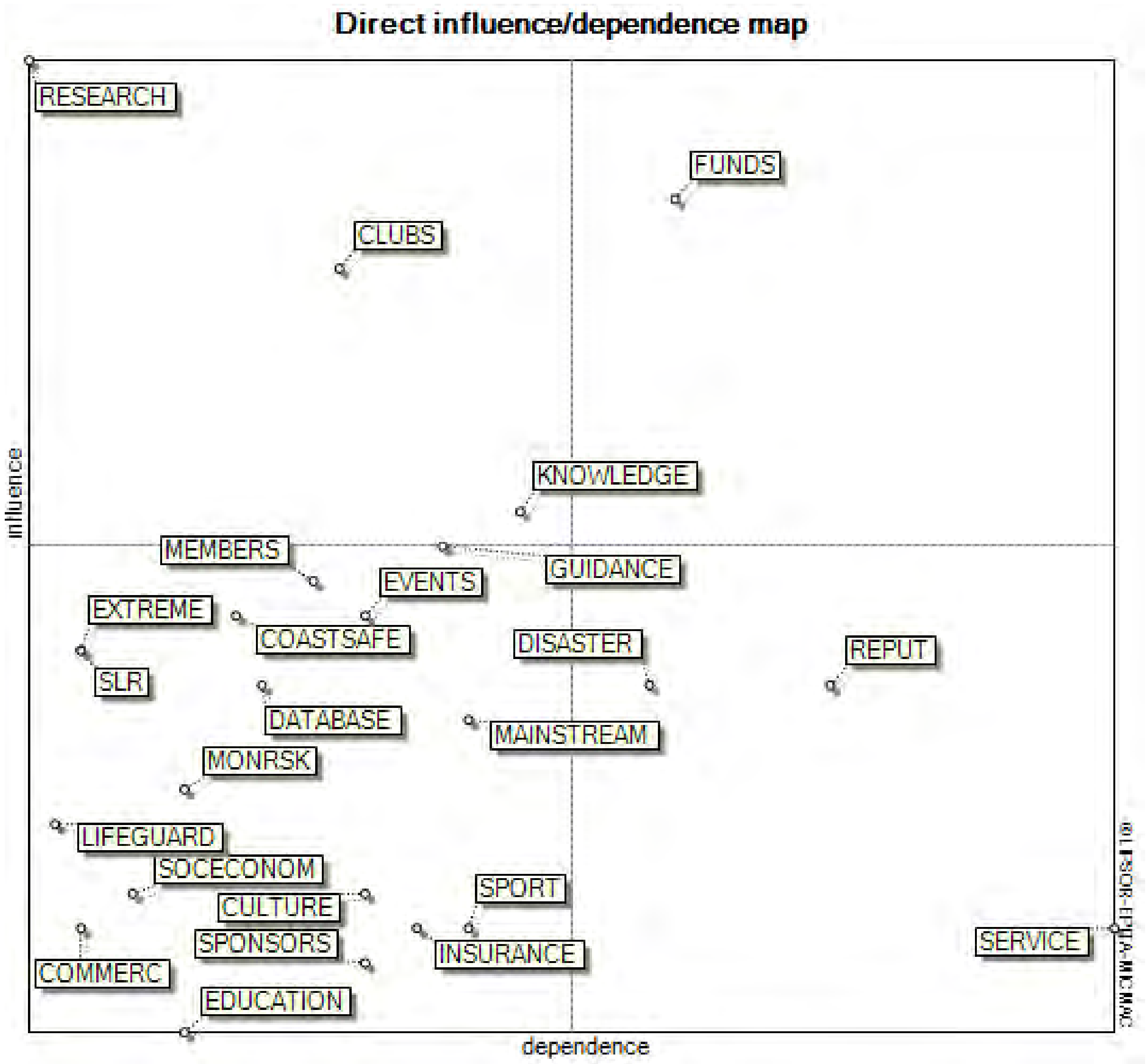


Figure 22: Direct influence/dependence map, SLSA

3.2.3 *Identification of essential variables*

Essential variables were identified using the MICMAC tool, then they were used to support decisions in identifying adaptation options for testing. Essential variables are here classified based on their influence and on the theme. Shaded cells are the adaptive responses selected for use in the second round of workshops. More influential adaptive responses were given priority over less relevant ones (Tables 12–15).

3.2.3.1 Cudgen Headland SLSC

Table 12: Classified variables according to their influence, Cudgen Headland SLSC

N°	LONG LABEL	SHORT LABEL	THEME	INFLUENCE
32	Beach nourishment	NOURISH	Adaptive response	2
34	Planned retreat	RETREAT	Adaptive response	3
12	Seawall	SEWAL	Adaptive response	5
31	Sand bags	SBAGS	Adaptive response	12
26	Training	TRAIN	Adaptive response	19
30	All weather access	AWACS	Adaptive response	24
33	Better equipment	EQUIP	Adaptive response	26
1	Beach	BEACH	Asset	1
8	Clubhouse	CLUB	Asset	6
28	Tourists	TOURS	Asset	8
9	Coastal dunes	DUNES	Asset	10
15	Visual amenity	LANDSCP	Asset	11
4	Boatsheds	BTSHD	Asset	13
2	Coastal vegetation	VEG	Asset	14
11	Public open space	OPSPACE	Asset	15
14	Vehicles	VEHIC	Asset	16
10	Membership	MEMB	Asset	18
3	Boat ramp	BTRMP	Asset	20
5	Bowling park	BWLPRK	Asset	22
7	Caravan park	CRVPARK	Asset	23
6	Car park	CARPARK	Asset	25
13	Surfing waves	WAVES	Asset	30
16	Offshore reefs	REEF	Asset	32
29	Local community	COMM	Community	7
18	Emergency services	EMSERV	Community	21
17	Board riders	SURFERS	Community	33
19	RSL	RSL	Community	34
21	Extreme storms	EXTRM	Driver of change	3
20	Population growth	POPGRWTH	Driver of change	9
22	Wave climate	WAVCL	Driver of change	27
24	Beach safety	SAFE	Operations	17
25	Surf carnival	CARNV	Operations	28
27	Sport training	SPTRAIN	Operations	29
23	ANZAC Day	ANZAC	Operations	31

Table 13: Classified variables according to their influence, Currumbin SLSC

N°	LONG LABEL	SHORT LABEL	THEME	INFLUENCE
32	Accommodate extreme water levels	ACCOM	Adaptive response	4
31	Life saving equipment	EQUIP	Adaptive response	5
27	Surf life saving training	SLST	Adaptive response	10
21	Rock	ROCK	Asset	2
24	Surfing wavers	WAVE	Asset	7
19	Nippers training facility	NIPFAC	Asset	11
28	View from the club	VIEW	Asset	13
1	Accessibility	ACCES	Asset	14
9	Competition equipment	COMPEQ	Asset	15
7	Building	BUILD	Asset	18
22	Rolling doors	ROLL	Asset	21
5	Boat and equipment shed	SHED	Asset	22
6	Boat ramp	RAMP	Asset	26
8	Car park	CARPARK	Asset	27
10	Creek	CREEK	Asset	28
14	Dunes	DUNE	Asset	29
2	Beach	BEACH	Asset	30
23	Storms	STRMS	Driver of change	1
26	Tourism	TOUR	Driver of change	3
12	Sea level rise	SLR	Driver of change	19
11	Cyclones	CYCLON	Driver of change	23
13	Economic trends	ECON	Driver of change	24
3	Erosion	EROSION	Driver of change	31
18	Membership	MEMB	Operations	6
20	Patrols	PTRL	Operations	8
25	Swimming sport	SWSP	Operations	9
29	Weddings	WEDD	Operations	12
30	Yearly events (Australia Day, ANZAC Day, etc.)	EVNT	Operations	16
4	Beach safety	SAFETY	Operations	17
17	Fitness	FITNS	Operations	20
16	Entertainment	ENTERT	Operations	25
15	Employment	EMPLOY	Operations	32

Table 14: Classified variables according to their influence, Ulverstone SLSC

N°	LONG LABEL	SHORT LABEL	THEME	INFLUENCE
23	Retreat	RETREAT	Adaptive response	5
22	Defend	DEFEND	Adaptive response	8
21	Equipment	EQUIP	Adaptive response	9
20	Training	TRAIN	Adaptive response	12
1	Beach	BEACH	Asset	1
2	Clubhouse	CLBHS	Asset	6
6	Location	LOCAT	Asset	10
4	Concrete steps and boat ramp	STPRMP	Asset	19
5	Land	LAND	Asset	20
3	Coastal dunes system	DUNES	Asset	23
8	Membership	MEMB	Community	3
9	Coastal tourism	TOUR	Community	11
10	Nippers	NIPRS	Community	14
7	Acknowledgement	ACKNOW	Community	16
11	Changing storms	STRMS	Driver of change	2
12	Unemployment	UNEMP	Driver of change	22
19	Sport	SPORT	Operations	4
17	Patrols	PATROL	Operations	7
18	Social activities	SOCIAL	Operations	13
14	Community awards	AWARDS	Operations	15
15	Emergency services	EMERG	Operations	17
13	Beach safety	SAFE	Operations	18
16	Swimming	SWIM	Operations	21

Table 15: Classified variables according to their influence, SLSA

N°	LONG LABEL	SHORT LABEL	THEME	INFLUENCE
3	Funding	FUNDS	Adaptive response	2
2	Adaptation guidance	GUIDANCE	Adaptive response	5
22	Disaster response support	DISASTER	Adaptive response	13
23	Mainstream Climate Change	MAINSTREAM	Adaptive response	14
24	Monitoring Climatic Risk	MONRSK	Adaptive response	15
1	National Insurance	INSURANCE	Adaptive response	17
8	Clubs	CLUBS	Asset	3
10	Knowledge capability	KNOWLEDGE	Asset	4
9	Membership	MEMBERS	Asset	6
4	CoastSafe	COASTSAFE	Asset	7
7	Reputation	REPUT	Asset	11
11	Databases	DATABASE	Asset	12
12	Culture	CULTURE	Asset	17
6	Service	SERVICE	Asset	20
5	Sponsors and partners	SPONSORS	Asset	23
14	Sea level rise	SLR	Driver of change	9
15	Extreme storms	EXTREME	Driver of change	10
13	Socio-economic change	SOCECONOM	Driver of change	18
17	Research	RESEARCH	Operations	1
18	Public events	EVENTS	Operations	8
20	Professional lifeguard services	LIFEGUARD	Operations	16
16	Sport	SPORT	Operations	21
21	Commercial operations	COMMERC	Operations	22
19	Education	EDUCATION	Operations	24

3.2.4 Adaptation options for testing

The outcomes of the previous analysis were useful to provide a better understanding of the possible adaptive responses to the risk of climate change. Based on the data collected and the analysis carried out in the previous phase, a set of five general options applicable to the clubs were identified for the second round of workshops when stakeholders were then asked to select a subset (typically three) to use as the focal point of the BBN development process. For the three SLSC case studies the adaptation options were focused on assets and operations at the club level (Table 16).

Table 16: Adaptation options to be tested at the club level (all clubs)

ADAPTATION OPTION	DESCRIPTION
Defend	Stay at current location of the asset and protect with external works (e.g. seawalls, dunes)
Retreat	Relocate the assets and place them at a location that is away from the impacts (of climate change)
Accommodate	Improve the assets' design standards to cope with extremes and future sea level rise.
Training	Incorporate coastal hazards and extreme events in the training curricula of surf life saving
Equipment	Identify potential equipment needs for the future

For the national body (SLSA) we selected the following adaptation options, based on the outcomes of our analysis and the available information from stakeholders (Table 17).

Table 17: Adaptation options to be tested at SLSA

ADAPTATION OPTION	DESCRIPTION
Improve partnerships	Strengthen partnerships with organisations to share and access information that supports coastal management and climate change
Club capacity building/ Adaptation guidance	Provide information to clubs on the risks posed by climate change and information for clubs (effective/non-effective)
Disaster response support	Provide direct support to clubs under threat or damaged by storms and cyclones
Mainstream climate change	Mainstream climate change into operational procedures to facilitate integrated management of climate risks within SLSA operations
Monitoring climatic risks	Establish mechanisms to monitor the impacts of climate change and other risks across the organisation (i.e. a climate risk-reporting framework)

3.3 System Dynamics modelling

The model built in Vensim DSS was designed to understand potential values of SLSC services given sea level rise controls, adaptation options, and feedbacks within and between the climate change and SLSA operations. The model consisted of three interactive sub-models: a) Climate change; b) SLSC Operations; and c) Community.

3.3.1 Climate change sub-model

The climate change sub-model included both sea level rise and changes in annual storm surge frequencies as they are vital to SLSCs' operation and assets (Figure 23). Simulation of the climate change sub-model under a range of sea level rise scenarios predicted changes in storm event frequencies.

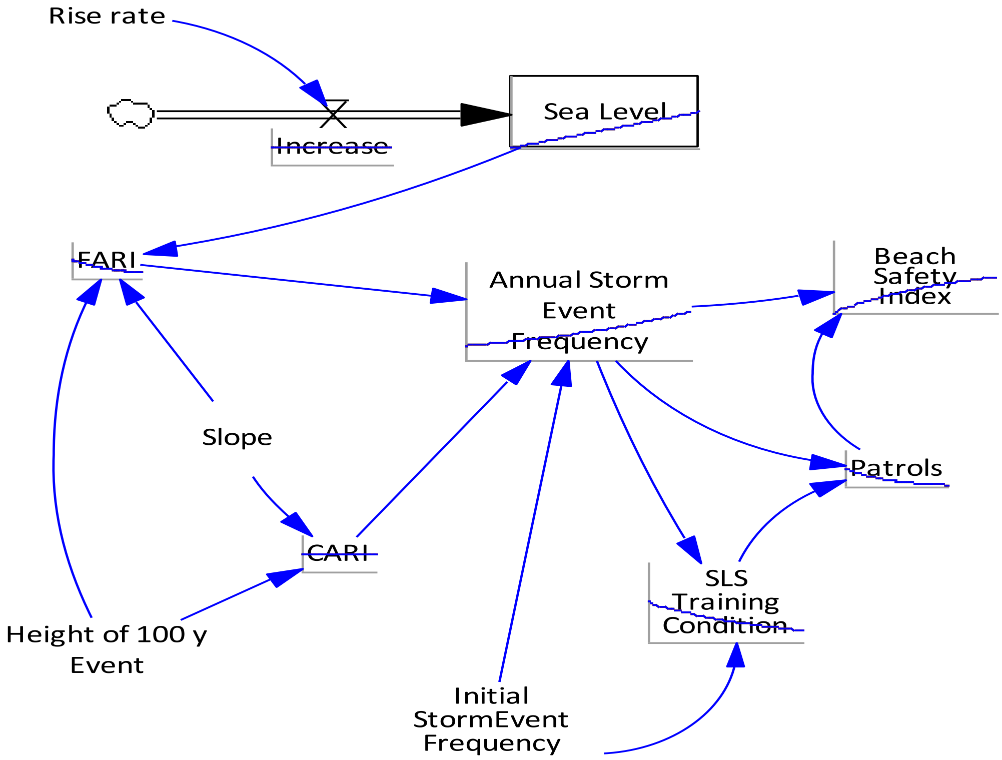


Figure 23: Climate change sub-model simulating sea level rise and resulting changes in a storm event frequencies

The climate change sub-model uses differential and difference equations to represent the interconnections in a system. The state variable, Sea Level, changes over time depending on the flow rate, Increase. The mathematical representation of the Stocks and Flows diagram (Figure 23) is shown below:

Stocks integrate flows (rates of change). That is:

Sea Level = $\int$(Increase) dt + [0] Eqn. 3
Increase = Rise rate Eqn. 4

Where Sea Level represents the sea level at time t while the Increase (t-dt) shows the rate of Increase at time (t-dt), [0] denotes initial sea level at the beginning of the simulation. Rise rate represents annual changes in sea level.

Annual Storm Event Frequency is the function of Initial Storm Event Frequency, Current ARI (CARI) and Future ARI (FARI), and was calculated using the following equation:

Annual Storm Event Frequency = InitialStormEvent Frequency* (CARI/FARI)
Eqn. 5

Where CARI represents the average, or expected, value of the periods between exceedance of a given storm event over a given duration at a location. FARI indicates the average return period of a storm event changing over time, depending on the sea level.

Harper et al. (2000) projected that the highest projected storm tide levels (relative to the Australian Height Datum – AHD) within the Moreton bay region (where Currumbin SLSC was located) for 50, 100, 500 and 1000 year storm events are 2.3 m, 2.5 m, 3.2 m and 3.5 m, respectively. By using the trendline of these projections and sea level data obtained at the previous step, equations 6 and 7 were created and used to calculate the CARI and FARI conditions:

$$CARI = 0.4094 \ln X + 0.6594 \qquad \text{Eqn. 6}$$

$$FARI = 0.4094 \ln X + (0.6594 + \text{Sea Level}) \qquad \text{Eqn. 7}$$

Where X represents the height of a given storm event. For this research, 1-in-100 year storm surge event was used for calculations.

Annual Storm Event Frequency was identified as one of the key variables affecting the SLSCs and used with a number of variables to simulate the impacts on clubs' operation and community as illustrated in Figure 24.

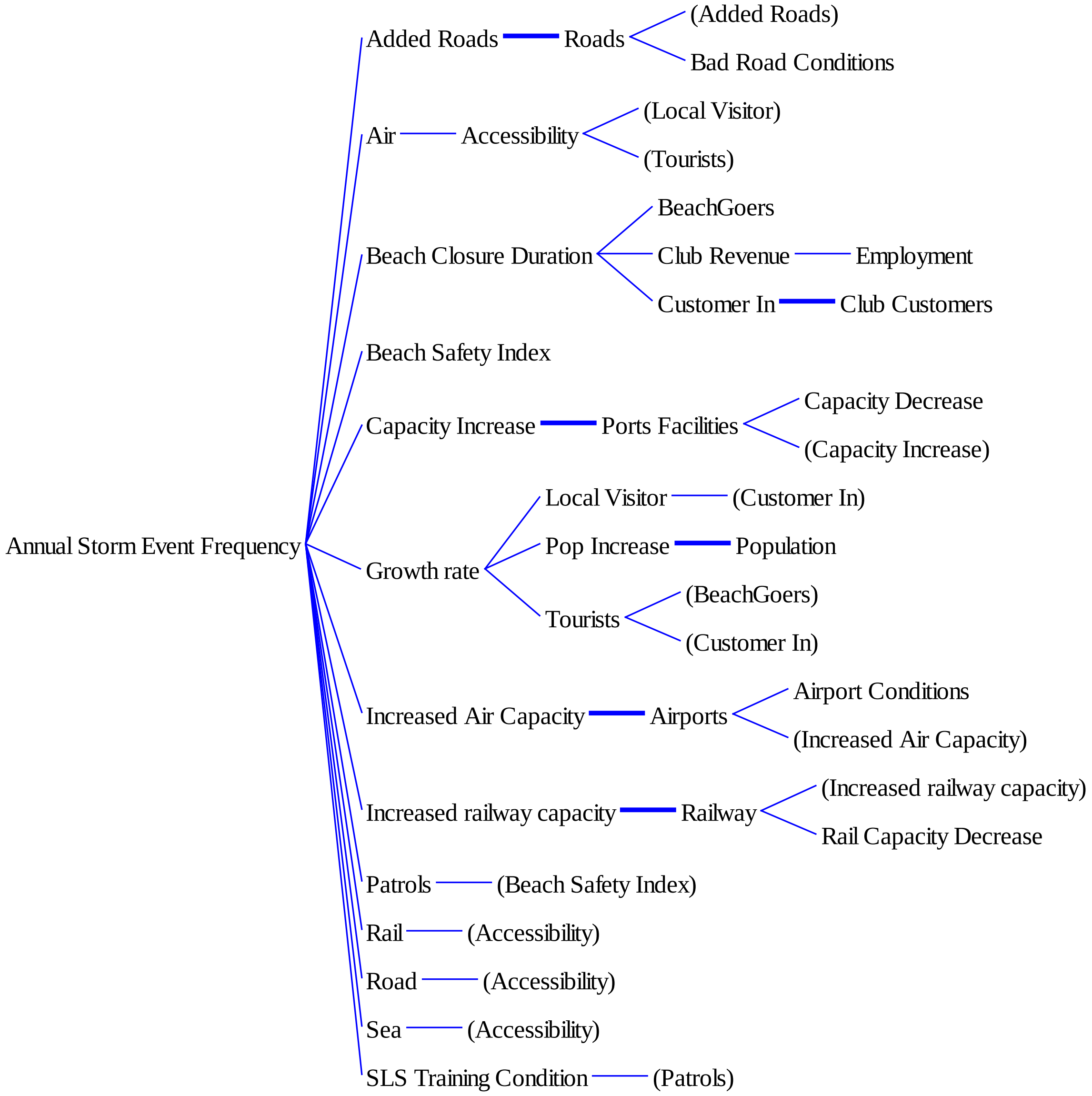


Figure 24: Influence tree for the Annual Storm Event Frequency variable

3.3.2 *Operations sub-model*

The operation sub-model consists of 35 variables, five of which are state variables (Figure 25). Accessibility was identified as one of the key factors affecting clubs' operation. Higher accessibility would bring more customers and, consequently, more revenue. Change in frequency of Annual Storm Events is the main problem as it causes beach and road closures. Therefore, adaptation investment on all forms of accessibility would reduce the impact of extreme storm events on the clubs' operation. The variable Club Customers relies on Accessibility, Local Visitors, Tourists and Beach Closure Duration and was computed using the following equations:

Club Customers $\int$ (Customer In-Customer Out) dt + [100] Eqn. 8

Customer In = (Local Visitor+Tourists)*Club Customers*(1-Beach Closure Duration/365) Eqn. 9

Customer Out = Club Customers Eqn. 10

Beach Closure Duration = Annual Storm Event Frequency*Recovery time Eqn. 11

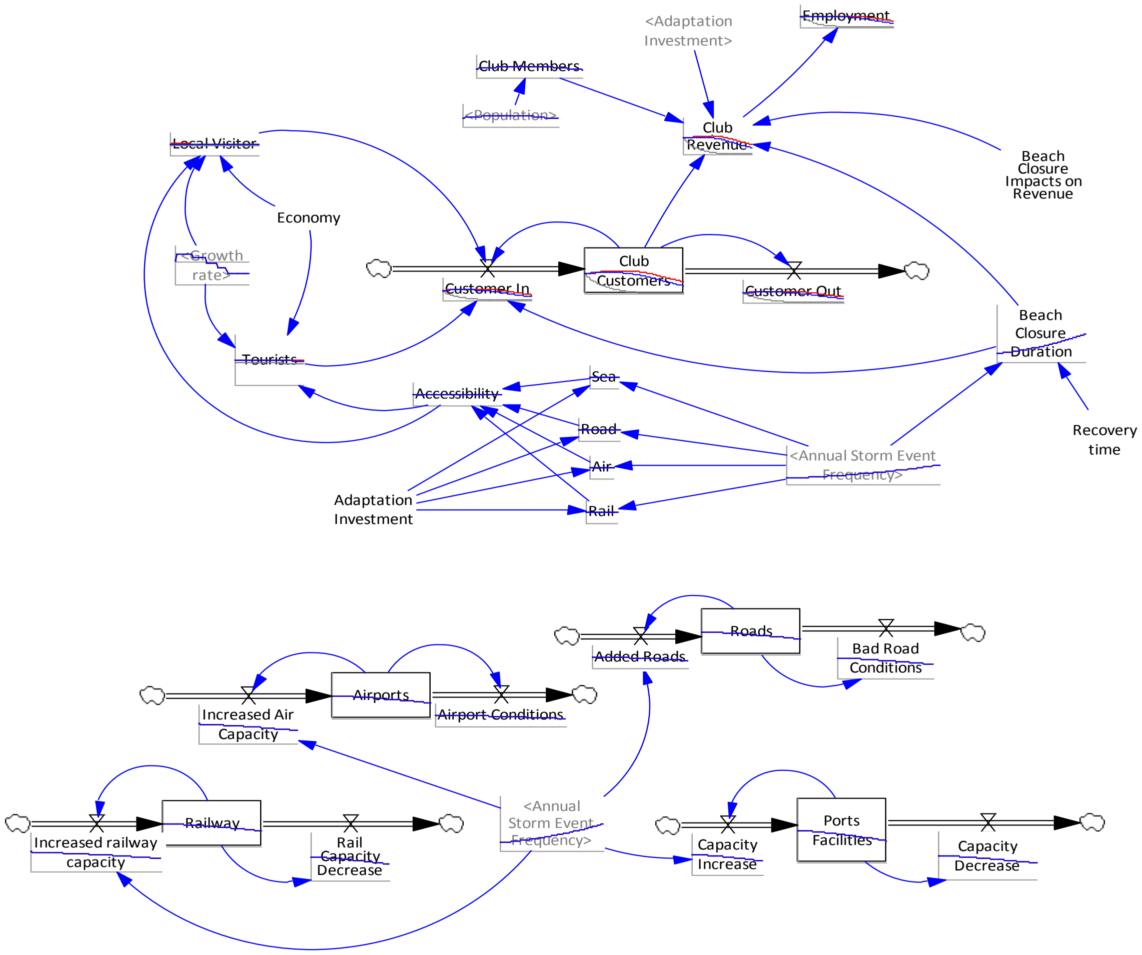


Figure 25: Operations sub-model showing the causal relationships between variables

Customer In calculates the average customer level. Initial level is assumed to be 100, and changes in customer level are calculated based on changes in Local Visitors, Tourists and Beach Closure Duration. Beach closure is the function of Annual Storm Event Frequency. It is assumed that beach will be closed during the storm events and

will be reopened after a few days, depending on the recovery rate. The number of days the beach remains closed over a year is calculated based on storm events and average duration of beach closure.

Another key variable, Club Revenue, is a function of Club Customers and Beach Closure Duration. It is assumed that the club revenue consists of (10%) membership fee and (90%) customer spending at the clubs. It is also assumed that during the beach closure, the number of customers will be reduced by 20%. However, in the model, this percentage point can be controlled with a slider so that various impacts of reduction scenarios can be tested. It is also assumed that investment in adaptation would reduce the negative impact by 50% by increasing the accessibility to the clubs during the extreme events.

3.3.3 Community sub-model

The community sub-model is used to understand the impacts of changing climate, specifically resulting extreme events, on community located around clubs (Figure 26). Increase in the local population clearly would create more potential to improve clubs' operations. Number of volunteers, beachgoers, memberships and club visitors/customers are directly influenced by the number of people residing in proximity. However, the population growth depends on the economic environment and quality of life. Increasing extreme events, according to stakeholders, may affect the population growth and economic growth negatively.

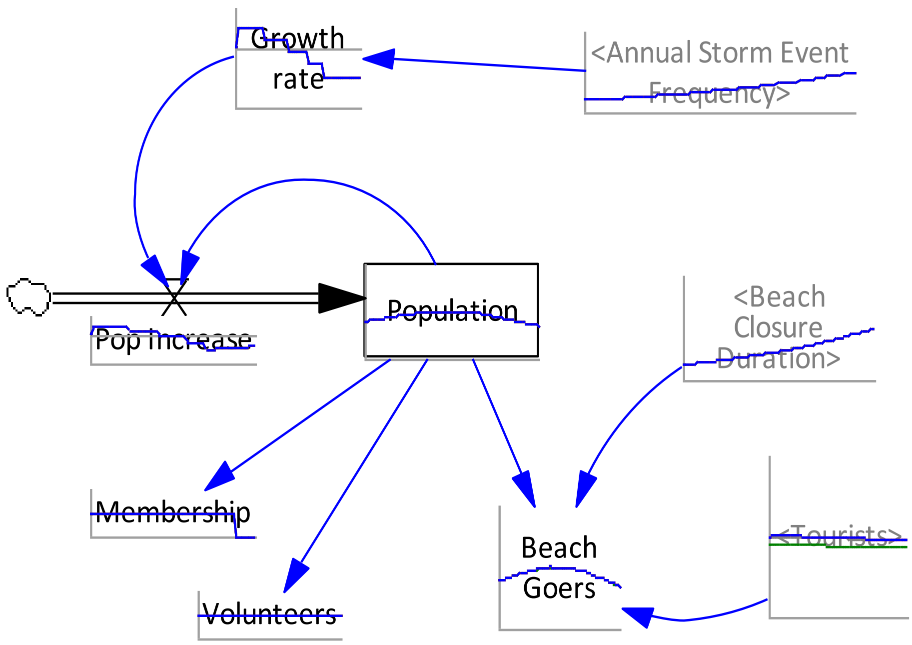


Figure 26: Community sub-model showing the relationships between variables

Population is calculated using the following equations:

Population $\int$ (Pop Increase) dt [100] Eqn. 12

Pop Increase = Growth rate*Population Eqn. 13

The following diagram shows the variables influenced by Population:

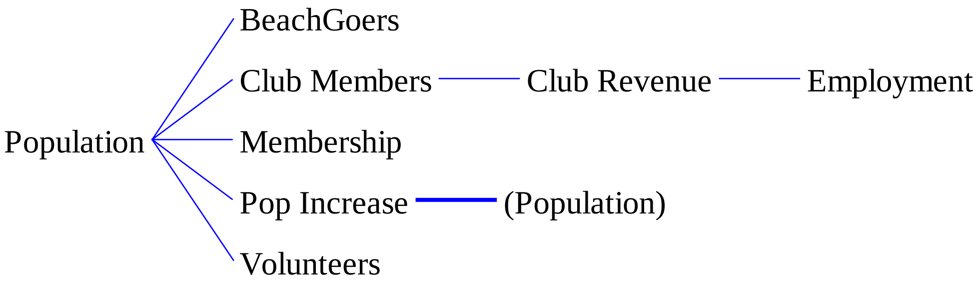
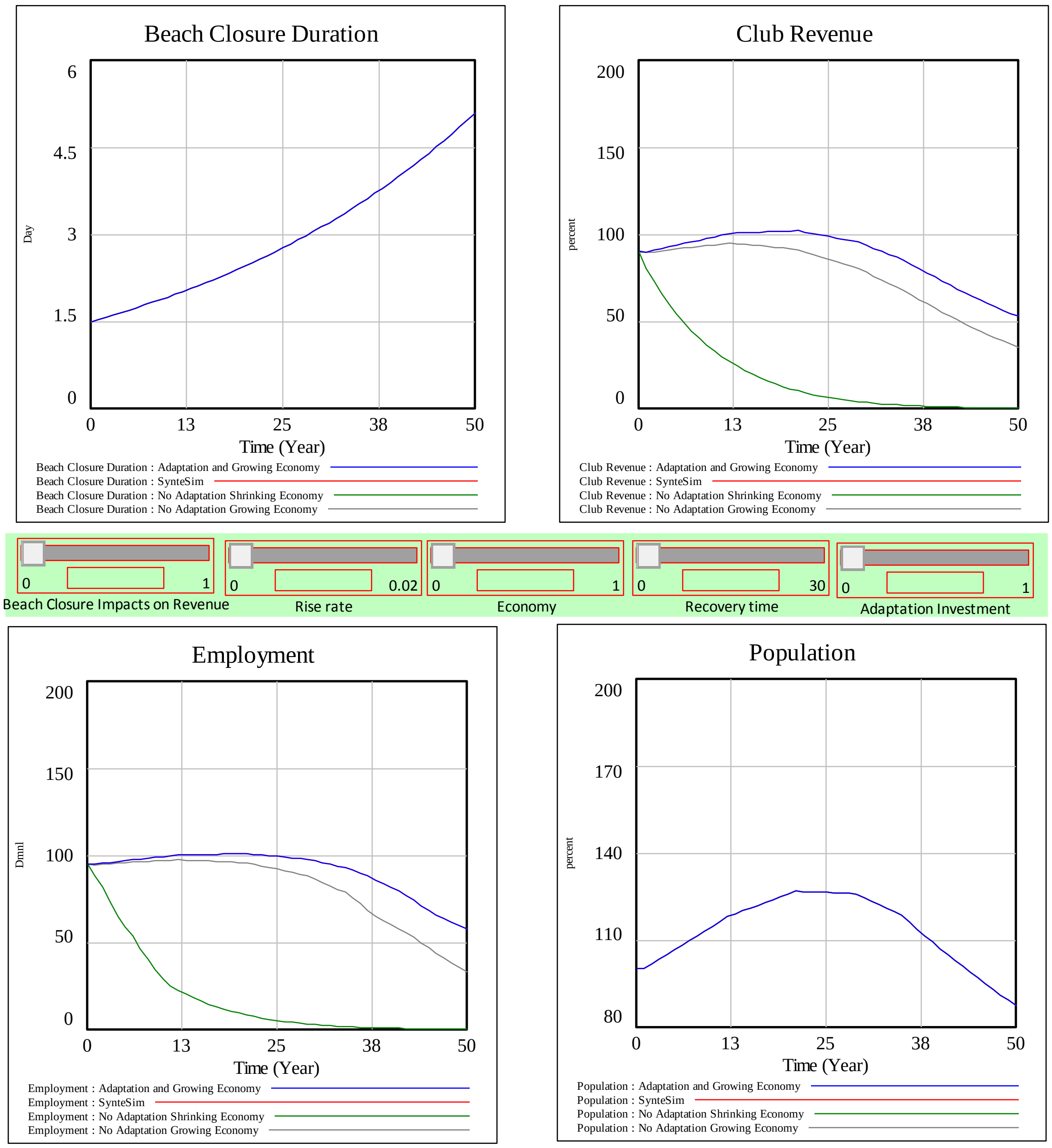


Figure 27: Influence tree for the variable Population

The simulation results under a range of scenarios are shown in Figure 28. Four scenarios, Adaptation and Growing Economy, No Adaptation with Shrinking Economy, No Adaptation with Growing Economy and SynteSim, were tested. The SynteSim run was created to provide the end users with greater control over changing the simulation parameters. Users can manipulate five sliders to change the value of Beach Closure, Economy, Recovery Time, Rise Rate and Adaptation Investment to evaluate their impacts on a range of variables.


Beach Closure Duration
6
4.5
3
1.5
0
Day
0
13
25
38
50
Time (Year)
Beach Closure Duration : Adaptation and Growing Economy
Beach Closure Duration : SynteSim
Beach Closure Duration : No Adaptation Shrinking Economy
Beach Closure Duration : No Adaptation Growing Economy
Club Revenue
200
150
100
50
0
percent
0
13
25
38
50
Time (Year)
Club Revenue : Adaptation and Growing Economy
Club Revenue : SynteSim
Club Revenue : No Adaptation Shrinking Economy
Club Revenue : No Adaptation Growing Economy
0
1
Beach Closure Impacts on Revenue
0
0.02
Rise rate
0
1
Economy
0
30
Recovery time
0
1
Adaptation Investment
Employment
200
150
100
50
0
Dmnl
0
13
25
38
50
Time (Year)
Employment : Adaptation and Growing Economy
Employment : SynteSim
Employment : No Adaptation Shrinking Economy
Employment : No Adaptation Growing Economy
Population
200
170
140
110
80
percent
0
13
25
38
50
Time (Year)
Population : Adaptation and Growing Economy
Population : SynteSim
Population : No Adaptation Shrinking Economy
Population : No Adaptation Growing Economy

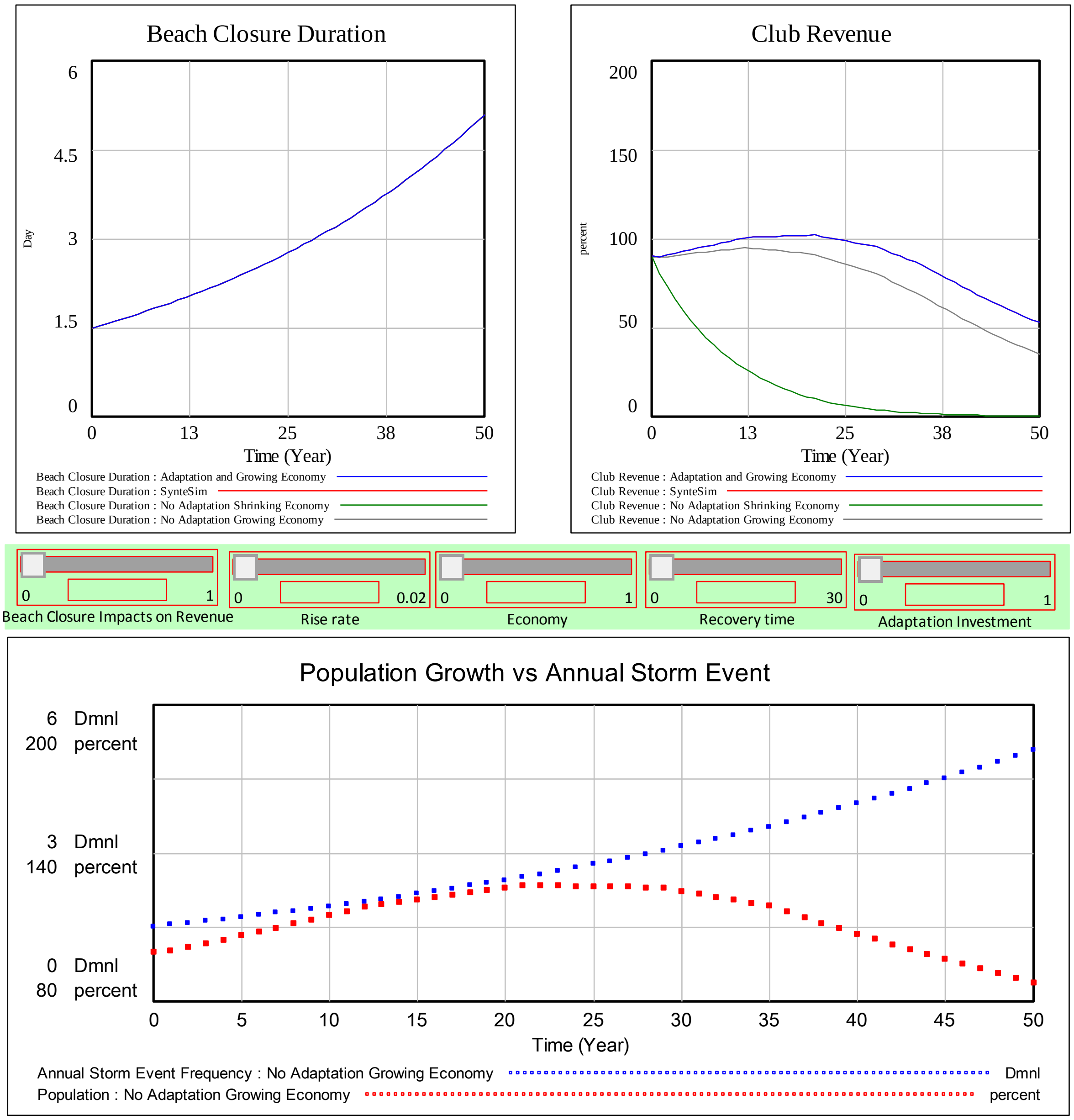


Figure 28: System Dynamics simulation output graphs

3.4 *Bayesian belief modelling*

3.4.1 *Process description*

The modelling process commenced with an overview of the project, provision of the latest climate projections (applicable to SLSCs, such as projections for sea level rise) and a summary of the results of the first workshop round. The aim of this was to provide an update of the research findings to date and to prime the stakeholders for the impending BBN modelling process.

The BBN development process began with a short presentation that provided an outline of the steps that the stakeholders would be taking in developing the structure of their BBN (i.e. an unpopulated BBN).

The stakeholders were shown how their selected adaptation option would be the starting point of their BBN (Table 18). They were then informed that they would create a variable around their adaptation option by discretising (assigning values) it with two states: a desirable state and an undesirable state. This was supplemented with additional information regarding the 'rules' that govern the discretisation of BBN variables: specifically, the states must address all possible outcomes, be mutually exclusive and be consistent for that variable (Uusitalo 2007). It was also highlighted that these states would be broad and qualitative.

Table 18: Summary of the stakeholder workshops and working groups on a specific adaptation option

WORKSHOP	ADAPTATION OPTION	STAKEHOLDERS
Cudgen Headland (NSW)	Retreat (relocate)	2
	Defend/Accommodate	2
	Surf life saving operations	2
Ulverstone (Tas)	Retreat	5
	Defend	6
	Water safety operations	2
North Kirra (Currumbin) (Qld)	Operations	2
SLSA (National)	Partnership	3
	Capacity building	2
	Mainstreaming climate change	2

Examples of variables that were not associated with this project (e.g. the colour of a car) were used to supplement this information. Finally, it was recommended that the stakeholders use 'effective' (desirable) and 'ineffective' (undesirable) as a starting point, although it was made clear that these could be changed. The rationale for recommending effective and ineffective were that (1) these were considered realistic states for the adaptation options proffered to the stakeholders, and (2) that it provided initial momentum for the development of the BBN by the stakeholders. Previous experience of stakeholder engagement in developing BBNs (Richards et al. 2012) has indicated that initially the stakeholders can be a little bit overwhelmed by the process, but they quickly grasp the concept (with the facilitation of the researchers present).

The stakeholders were then provided with the following prompting statement:

“Identify the variables that directly influence your capacity to implement the adaptation option.”

They were asked to select a maximum of three primary variables and recommended to discretise these with a maximum of two states: a ‘desirable’ and an ‘undesirable’ state. However, there were some (few) instances where it was more informative to assign states that did not necessarily reflect a desirable and undesirable state but rather reflected the two possibilities. They were also instructed to make these primary variables independent from one another (within reason) so that the states of one of these variables were not influenced by, or had influence on, another.

The rationale for limiting the number of states to two for all of the variables is that it makes the associated conditional probability tables (CPTs) that are populated as a latter part of the BBN development process (see below) more tractable (Richards et al. 2012). The stakeholders were informed that this was a pragmatic decision related to being able to develop the model, although the specific consequences of this decision were not highlighted until after the CPTs were completed so the stakeholders were not biased into developing BBN structures with less variables motivated by smaller CPTs.

A follow-up statement was then provided that emphasised direct causality:

“Identify the variables that directly influence these primary-level variables.”

Again, the stakeholders were instructed to assign two states to these secondary variables using the same guiding rules as for the primary-level variables.

The result of this process was the development of what is known as a directed cyclical graph (DAG) or a causality tree, characterised by two hierarchical levels, with each child node having a maximum of three parent nodes.

The final step of this process was to get the stakeholders (as a group) to assign percentages to the variables at the primary and secondary hierarchical levels that represented the relative influence of each parent node on a particular child node.

Conditional Probability Tables

CPTs are used in BBNs to quantify the strength of causality between a group (which can be a single node) of parent nodes and the child node that they are directly connected to. Contrasting the development of the BBN structure (based on the collective belief of workshop participants), the CPTs were populated based on individual stakeholder beliefs. These data were obtained through the stakeholders assigning percentages to the CPTs that represented their belief in the strength of these relationships. More detail on this process is provided in Richards et al. (2012).

Post-workshop

After the workshops, the data elicited from the participants were used to construct and compile functioning BBNs using the dedicated Bayesian software package Netica (Norsys 2012). Auxiliary ‘expert’ variables were introduced to each of the BBNs (Kjærulff and Madsen 2008). These auxiliary variables were specified for every child variable within the BBN structure with the contribution of each stakeholder’s CPT weighted equally.

The BNs were then subjected to sensitivity testing to evaluate the relative influence of every variable within the network on the focus variable (i.e. the adaptation option). This

process provides a formal process for identifying the influential pathways and leverage variables within each of the developed BBNs. It also allows the impact of the individual stakeholder beliefs on the model functioning to be examined. This last aspect is important because stakeholders can have strong but opposing beliefs about the strength of the relationships between the variables, or a sub-set of variables within a BBN.

The following section outlines the BBNs that were developed through the four case study workshops.

3.4.2 *Identification of influential adaptive capacity variables and pathways*

The following is a closer inspection of each of the ten BBNs based on the sensitivity analyses that were carried out. The outcomes of the individual sensitivity analyses are tabulated in Appendix 3.

3.4.2.1 Cudgen Headland SLSC

The six stakeholders were separated into three groups of two with each group developing a BBN around a specific adaptation option. From the five adaptation options (themes) that were presented, the stakeholders selected *retreat*, *defend* and *surf life saving operations* as the focal variables for BBN development.

Adaptation option – Retreat

The developed network for this adaptation option is presented in Figure 29. The stakeholders contextualised this adaptation option (i.e. retreat) as relocation along the beach to a location that was less vulnerable to sea level rise and erosion because of geographical constraints of moving inland from the current location. That is, they considered it was at least as likely (if not more) that retreat would entail moving along the beach rather than inland from it. A key issue of this adaptation option was centred on what impact this relocation would have on the ability of the club to maintain expected services to SLSA and the public, for example, on connection with the community in terms of visibility and the capacity to provide the required surf life saving services at distance from the club house.

The sensitivity analysis highlighted that the most influential issue was having sufficient funding to undertake the retreat/relocation. This in turn, was most dependent on the funding stream from the local government (council rate base). Safety of swimmers emerged as the next most influential issue, and this was wholly dependent on the capacity of the SLSC to provide this safety. Finally, the auxiliary stakeholder (not shown in Figure 29) variable that represents the effect that their individual beliefs are convergent (or divergent) was mid-ranked in terms of the influence that it has on the priority issue. This indicates that the beliefs of the two stakeholders were generally convergent.

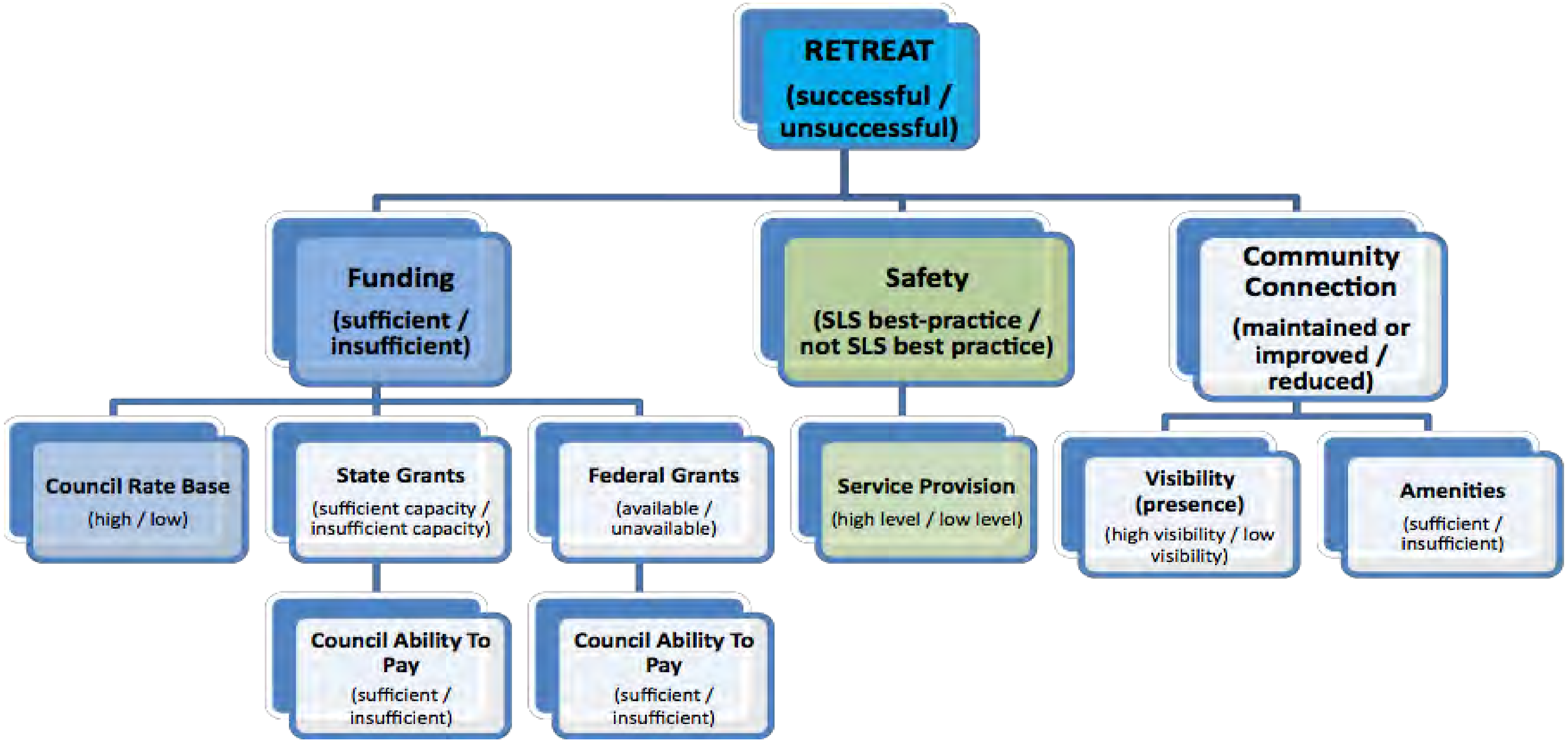


Figure 29: BBN developed for the adaptation option of successful retreat (relocation), Cudgen Headland SLSC

Adaptation option – Defend/accommodate

Figure 30 shows the BBN that was developed around defending/accommodating the Cudgen Headland SLSC assets from the impacts of climate change. The two stakeholders involved in developing this BBN structure also participated in populating the associated CPTs.

The most influential variable influencing the ability of the club to effectively *Defend/Accommodate* climate change is *Funding*. This is clearly the key issue in this BBN as perceived by the stakeholders, so much so that the next most influential variable is *Government*, which is a parent node for *Funding*. Thus, based on the beliefs of these stakeholders, effective Defence/Accommodation is strongly dependent on whether Government is *safe* (desirable) or *marginal* (undesirable).

Of the other primary-level variables, *Engineering Design* and *Stakeholder Management* have similar influence (which is much less than Funding).

Finally, the auxiliary variable *Stakeholder* is relatively influential, which indicates some divergence on the probabilities assigned by the two stakeholders. However, this does not necessarily mean that the two stakeholders have diverging beliefs; they might have similar beliefs about the relative importance of the different variables and thus the divergence simply reflects different probabilities assigned by them.

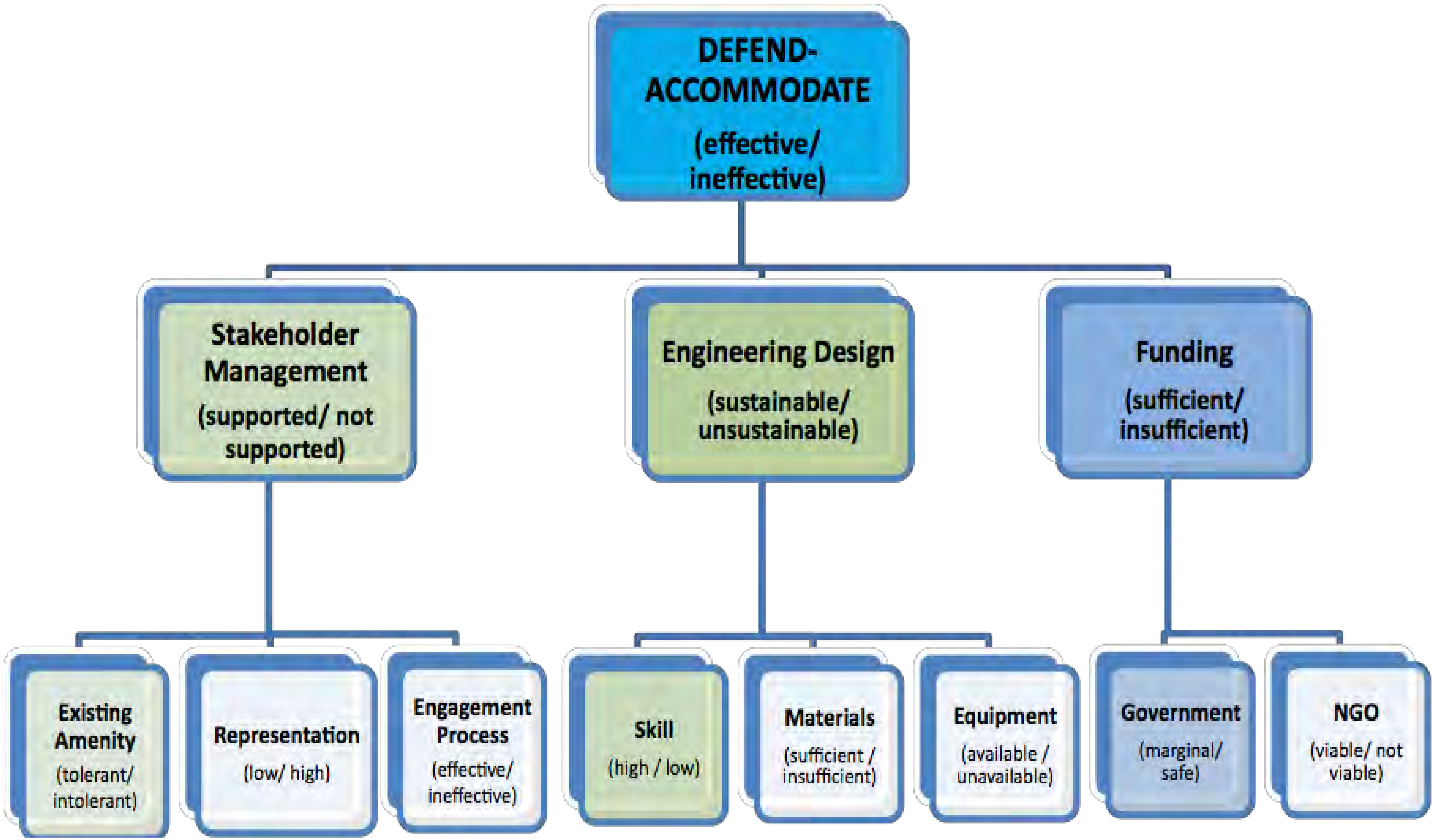


Figure 30: BBN developed for the adaptation option of maintaining effective defence, Cudgen Headland SLSC

Adaptation option – Surf life saving operations

Two stakeholders were involved in the development of the network structure for this BBN (Figure 31) but only one CPT was developed.

The sensitivity analysis (via the 'variance of beliefs' metric) indicates that the three primary-level variables are approximately equitable in their influence on the adaptation option. At the second hierarchical level, *Trainers* is the most influential on *Training*, *SLS Culture* is the most influential on *Volunteering* and *Fundraising* and *Membership Fees* are equally influential upon *Funding.*

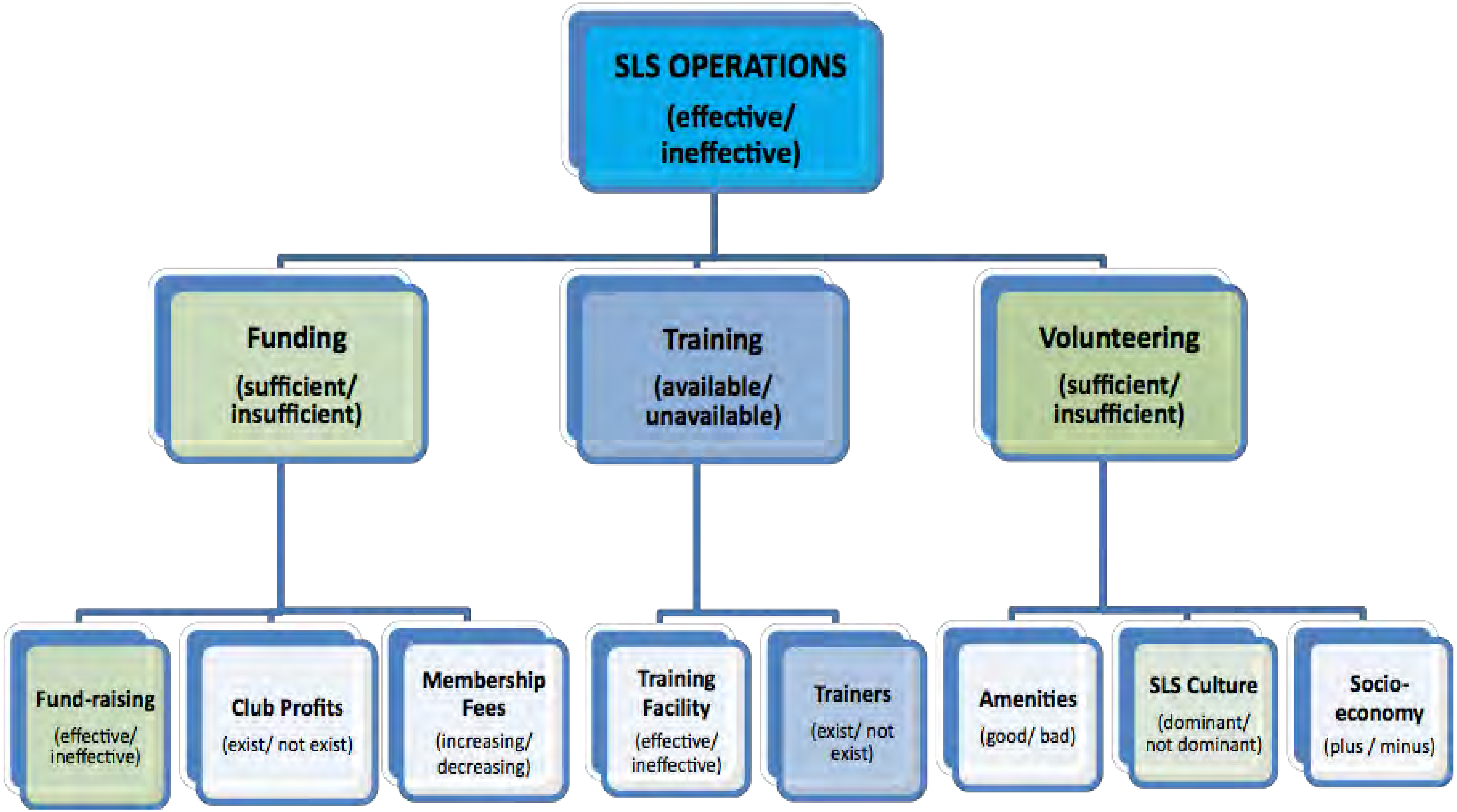


Figure 31: BBN developed for the adaptation option of maintaining effective surf life saving operations, Cudgen Headland SLSC

3.4.2.2 Ulverstone, Tasmania

From the five adaptation options that were presented, the stakeholders selected *retreat*, *defend* and *surf life saving operations* as the focal variables for BBN development. Of the 13 stakeholders who attended this workshop, most expressed a desire to explore the asset management–related adaptation options (i.e. retreat, defend). Consequently, six stakeholders were involved in the development of the BBN around *retreat*, five were involved in the *defend* BBN and only two stakeholders worked on the BBN that was developed around *surf life saving operations*.

Adaptation option – Retreat

All of the stakeholders involved in the development of the model network structure also participated in populating the CPTs, hence there are six sets of CPTs elicited for this BBN. Figure 32 shows the network and also highlights the relative influence of different primary- and secondary-level variables on the adaptation option. The auxiliary variable for the individual *Stakeholders* (not shown in Figure 32) indicated that there is a fair amount of agreement in their individual beliefs and what they consider to be important variables.

Of the three primary-level variables, *Inertia* emerged as slightly more influential (on retreat) than *Funding*, while both were noticeably more influential than *Future Requirements*.

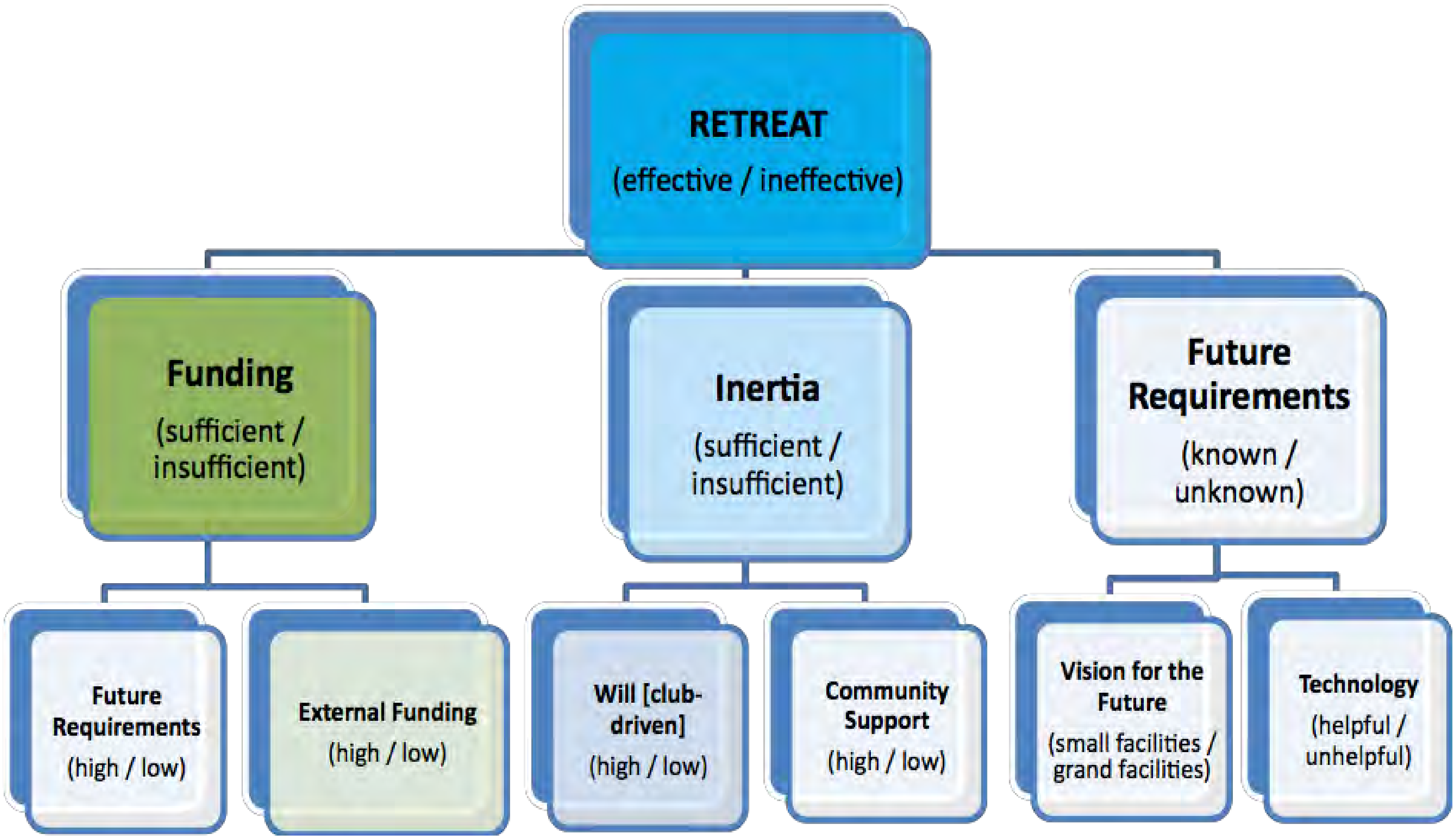


Figure 32: Ulverstone SLSC 'Retreat' sensitivity pathways

Note: blue is most sensitive, green is second highest

Adaptation option – Defend

Five stakeholders were involved in developing the network structure (Figure 33) but only two participated in populating the CPTs.

Based on the conditional probabilities provided by the two stakeholders involved in this process, *knowledge and expertise* is clearly perceived as being the variable most influential on whether defending the asset against climate change will be effective. This primary-level variable is equally influenced by the three variables acting on it (*access to information*, *engineering expertise*, *scientific and research expertise*).

Having sufficient *funding* is the most important or influential variable in defence of the asset and this is mainly determined by *availability of resources* and *awareness of funding opportunities*.

The auxiliary stakeholder variable is ranked near the bottom of the sensitivity analysis (refer Table A3.1 in Appendix 3), which indicates that the beliefs of the two stakeholders involved in the CPTs were similar.

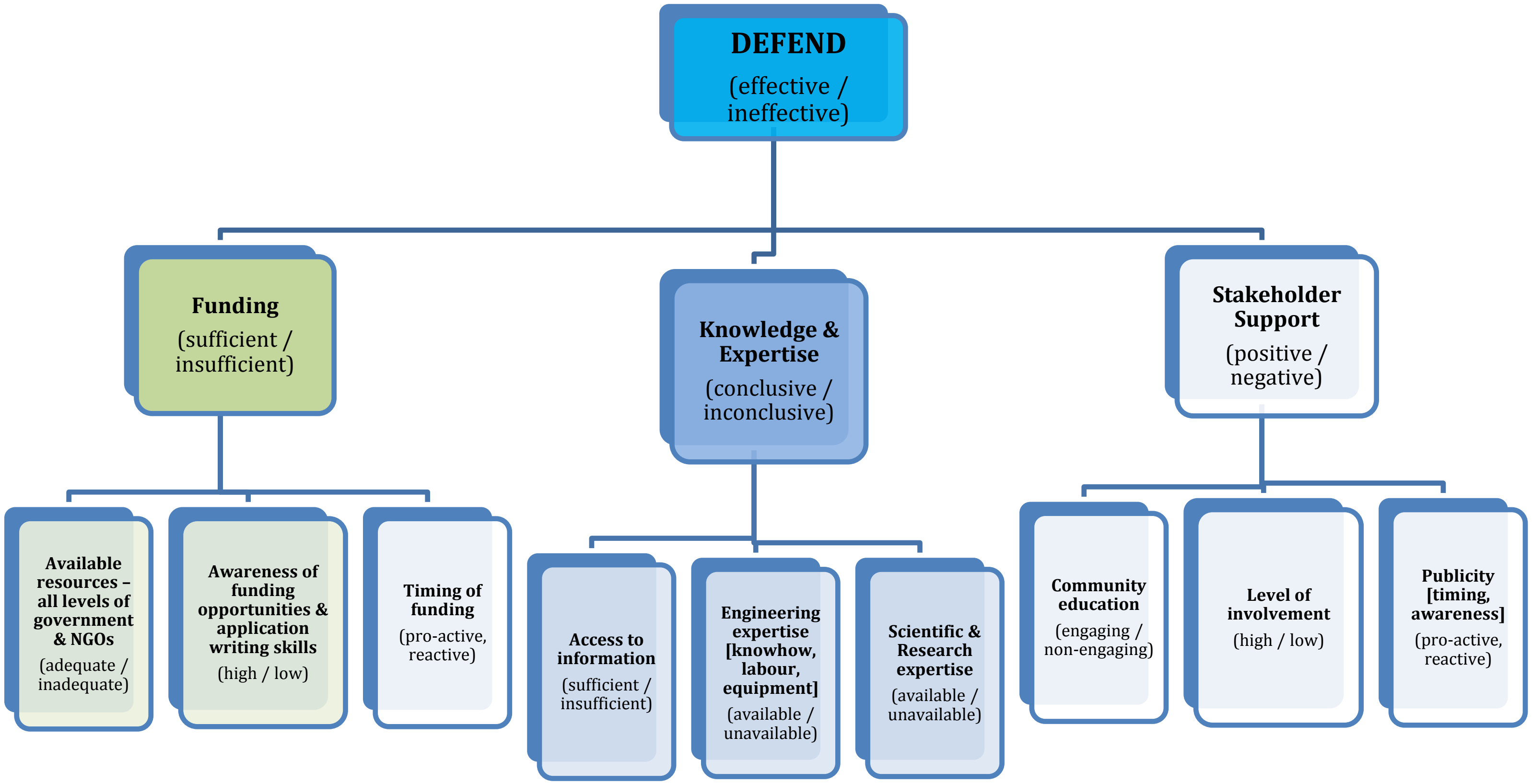


Figure 33: Ulverstone SLSC 'Defend' sensitivity pathways

Note: blue is most sensitive, green is second highest

Adaptation option – Operations

Note that the two stakeholders that were involved in the development of the BBN structure (Figure 34) combined to create a single set of conditional probabilities for the model and therefore there is no auxiliary variable representing the stakeholder effect.

The primary level variable *People* is clearly the most influential variable here. In turn, it is almost equally dependent on *Experience* and *Membership* (secondary-level variables). *Accessibility* (to the clubhouse) is the second most influential variable at the primary level of the BBN; however, it should be noted that (a) this is much less influential than *People* and (b) it is only slightly more influential than *Equipment*. At the secondary level, the *Design of the facility* is an important determinant, but the context is that *Accessibility* itself is not particularly important.

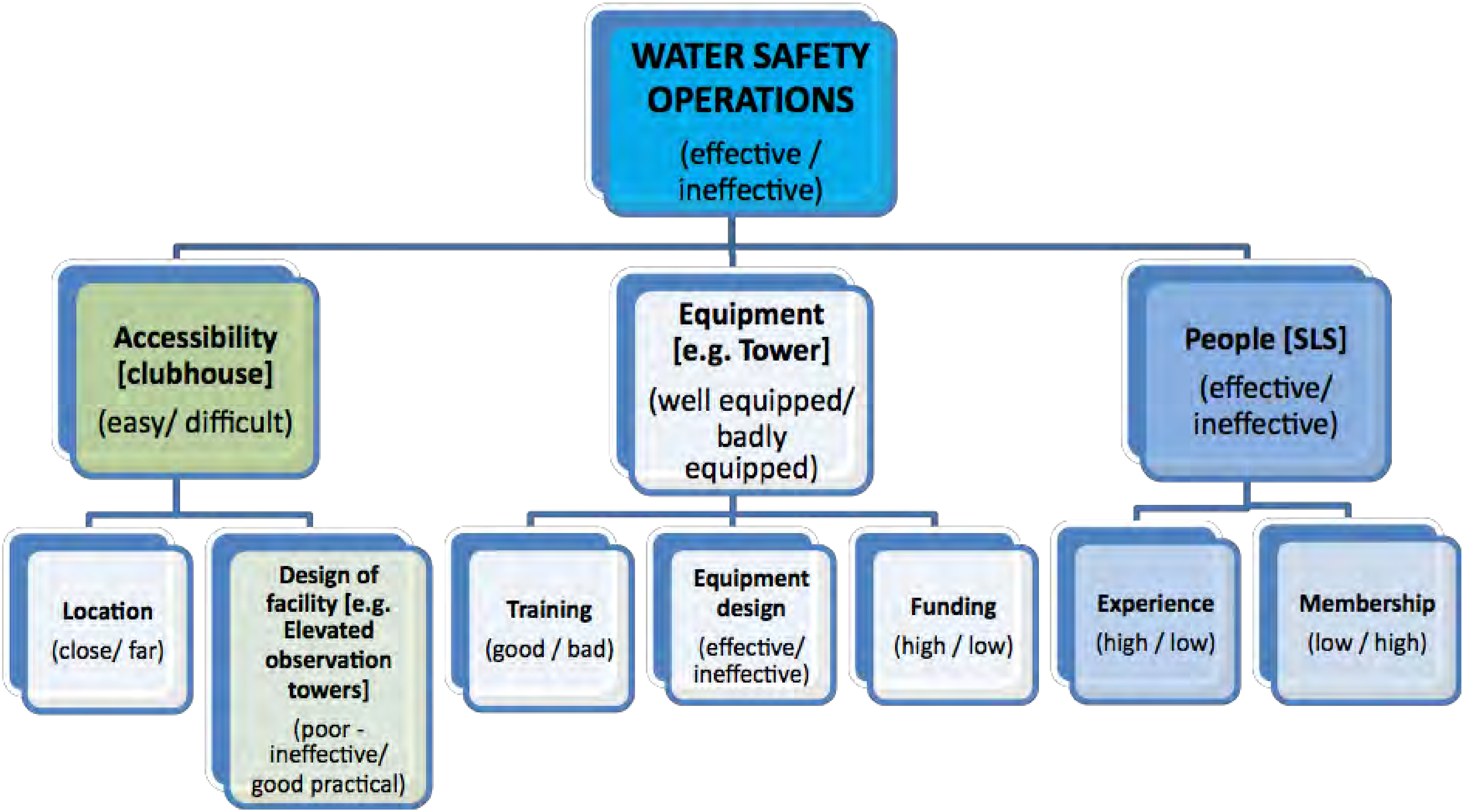


Figure 34: Ulverstone SLSC 'Water safety operations' sensitivity pathways

Note: blue is most sensitive, green is second highest

3.4.2.3 North Kirra, Queensland

The Currumbin SLSC club participated in the first round of stakeholder workshops. However, they did not participate in the second round where the Bayesian network models were developed.

North Kirra SLSC is located alongside a long wide sand beach, which contrasts with the Currumbin SLSC, which is 'perched' on Elephant Rock at the entrance of the Currumbin Creek tributary system. Consequently, the vulnerability of the assets of these two SLSCs is distinctively different.

However, North Kirra SLSC is located close to Currumbin SLSC and therefore shares similarities in terms of operations in the context of similar patronage and governance (both are subsumed within the same management region). Therefore, given the limited number of stakeholders involved (n=2) coupled with the differing vulnerability characteristics for North Kirra compared with Currumbin but the similar operating environment, it was decided that a single BBN would be developed that focused on the adaptation option of maintaining effective operations under climate change.

The results of the sensitivity analysis are summarised as follows. The number of *Trained Members* (and whether there were sufficient numbers or not) was the most influential determinant of maintaining effective *operations*. Having appropriate *equipment* also emerged as being important as a direct determinant of *operations*.

At the secondary level, the *Number of Beachgoers* was important, presumably because it acts through two pathways (via *Trained Members* and also *Equipment*). However, it is likely that it acts mainly through (the number of) *trained members* because this is an influential variable – this is confirmed by looking at the associated CPTs.

Club Revenue is also influential on operations. This variable acts through all three primary-level variables, which probably explains its high influence. However, it is probably most influential through *equipment* because *equipment* itself is influential. Again, a review of the CPTs supports this theory.

Finally, the effect of the different beliefs of the stakeholders (quantified through the auxiliary variable) is low, indicating general convergence in the probabilities that they assigned.

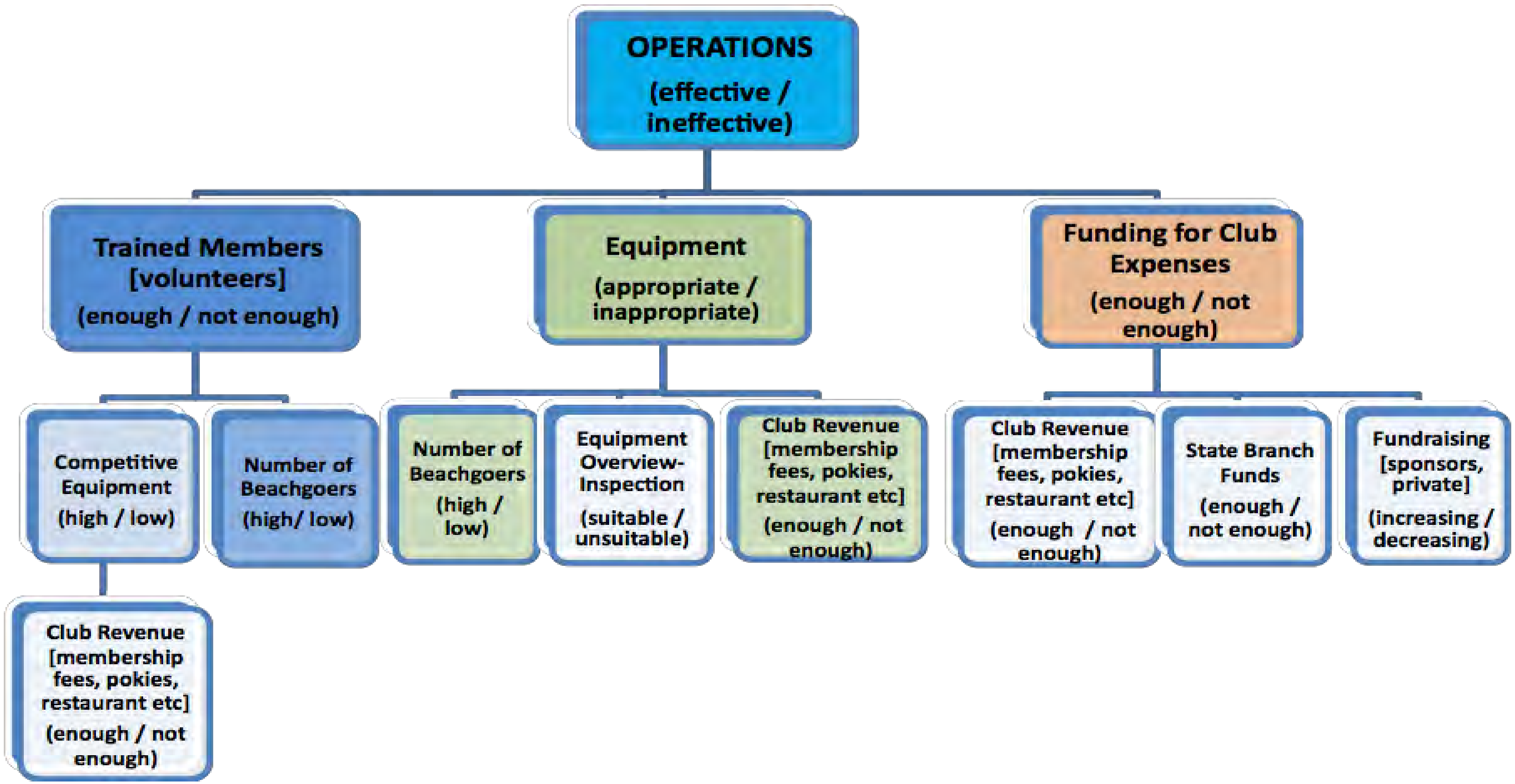


Figure 35: North Kirra SLSC 'Operation' sensitivity pathways

Note: blue is most sensitive, green is second highest, and orange is least

3.4.2.4 SLSA

Five stakeholders were involved in developing three BBNs and all participated in populating the CPTs. Of the five adaptation options that were presented to the stakeholders by the researchers (determined by the researchers prior to the workshop based on the findings of the first round of workshops and literature review), the stakeholders nominated *Mainstreaming climate change*, *SLSA capacity* and *Partnerships* as the three options to be explored using the Bayesian modelling.

Adaptation option – Mainstreaming climate change

Two stakeholders were involved in developing this BBN (Figure 36). The sensitivity analysis showed that *Attitude* was the main determinant of *Mainstreaming climate change* into SLSA policy, and that this in turn was strongly dependent on whether (*Mainstreaming climate change*) was core business or not. The variables *Member education awareness* and *Type of activities* represented the next most influential pathways affecting *Mainstreaming climate change*.

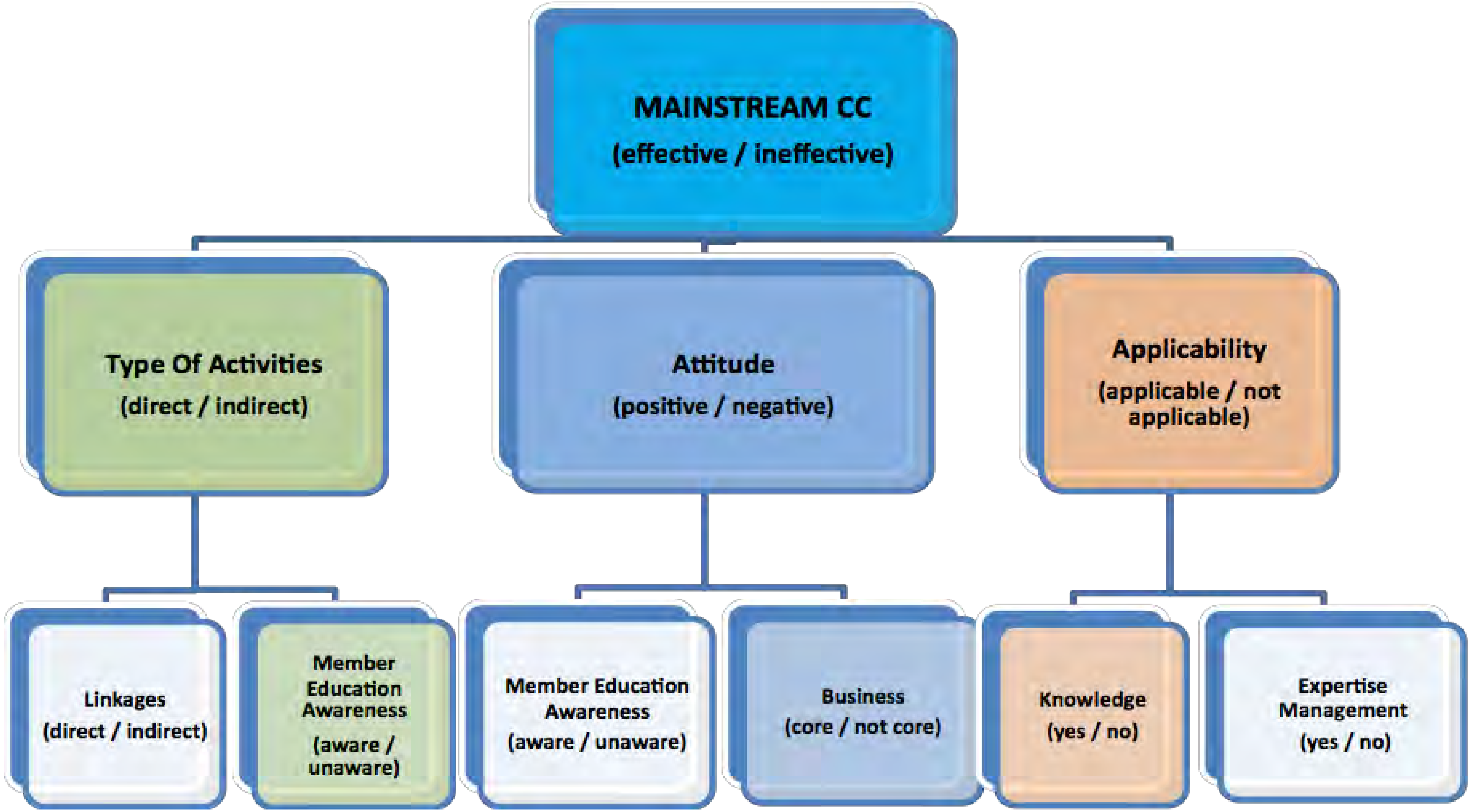


Figure 36: SLSA 'Mainstream CC' sensitivity pathways

Note: blue is most sensitive, green is second highest, and orange is least

Adaptation option – SLSA Capacity

Two stakeholders were involved in the development of this BBN (Figure 37). Based on the sensitivity analysis, the most influential pathway of variables (acting on the adaptation option) was through *Membership base* and *Networks-communication*. The *Relationships-partnership* and *Funding* pathways were also influential.

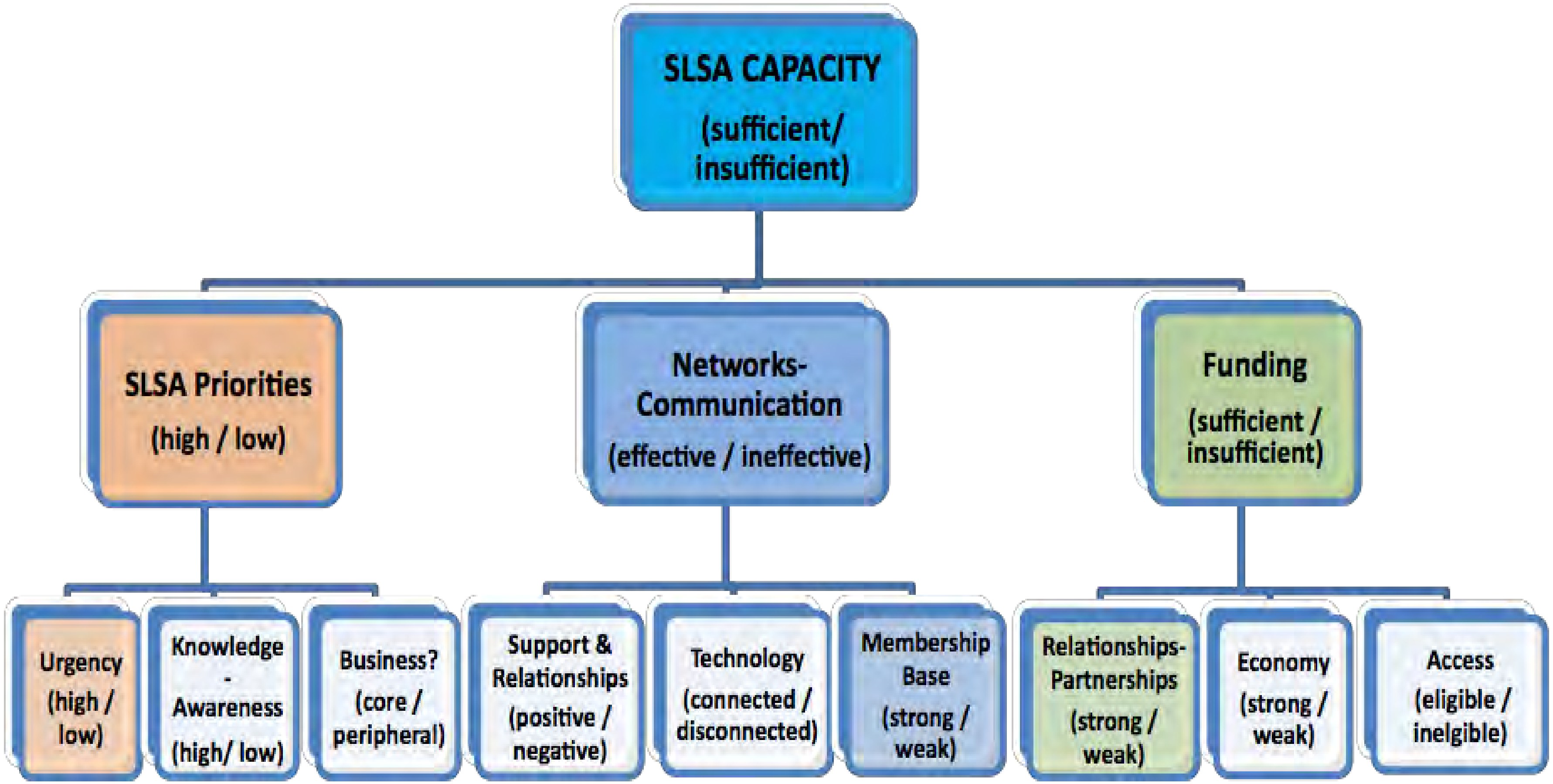


Figure 37: SLSA 'SLSA Capactiy' sensitivity pathways

Note: blue is most sensitive, green is second highest, and orange is least

Adaptation option – Partnership

Three stakeholders were involved in developing this BBN (Figure 38). The sensitivity analysis showed that the dominant node is *Relationships & connections*, which is clearly the most influential node acting on *Partnership*. The dominance of this variable is such that the three most influential pathways act through *Relationships & connections*.

The other two primary-level variables (*Reputation* and *Knowledge*) have similar influence on the adaptation option, but this is much lower than was observed for *Relationships & connections*.

Finally, the auxiliary variable for stakeholder effect is mid-table and therefore indicates a moderate level of divergence (and thus convergence) between the probabilities assigned by the three stakeholders involved.

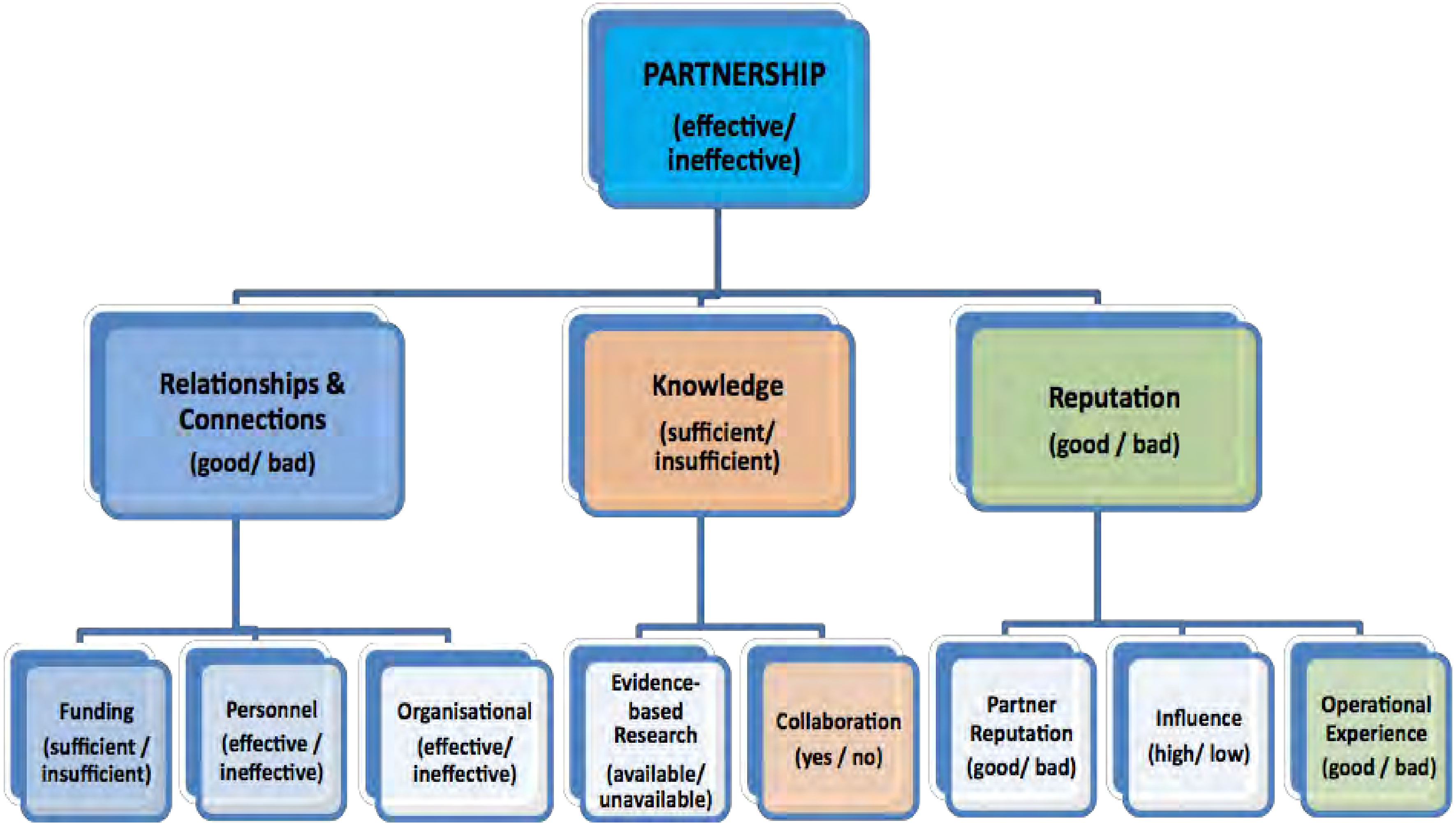


Figure 38: SLSA 'Partnership' sensitivity pathways

Note: blue is most sensitive, green is second highest, and orange is least

3.4.3 Enhancing adaptive capacity

A summary of the key determinants is presented in Table 19, classified by the case study, including a set of actions to enhance adaptive capacity. The table also includes possible actions designed to enhance adaptive capacity identified by the research team. These are then narrowed down to a set of ten actions presented in section 4.3.

Table 19: List of most influential determinants of effective implementation of the adaptation option for the three SLSCs and the SLSA, and identified measures to enhance adaptive capacity

CASE STUDY	ADAPTATION OPTION	ADAPTIVE CAPACITY DETERMINANTS OR CONSTRAINTS	NOTES	POSSIBLE ACTIONS TO ENHANCE ADAPTIVE CAPACITY
Cudgen Headland	Retreat	Funding	Funding from local government	Create mechanisms to access funding sources
		Beach safety	Capacity to provide this service if the asset is removed	Provide access to alternative equipment to keep a presence at the beach, e.g. removable buildings
	Defend and Accommodate	Funding	Related to government stability	Create mechanisms to access funding sources
		Engineering design	/	Inform clubs about possible adaptation options
	Operations	Training programs	Training occurs (availability of trainers)	Integrate coastal hazards and climate change in surf life saving training programs
		Funding	Funding (internal sources e.g. fundraising)	Improve fundraising mechanisms
Ulverstone	Retreat	Community will	Sufficient inertia to retreat (the 'will' to move is provided by the SLSC)	Provide information to the community about existing options
		Funding	Sufficient funding to retreat (external funding; capacity to obtain funding e.g. grant-writing skills)	Create mechanisms to access funding sources
	Defend	Knowledge and expertise	Knowledge and expertise (equally dependent on having access to information, the engineering expertise available and the scientific and research expertise available)	Provide technical information to clubs
	Operation	Quality of trained staff	Having effective people within the club (having experienced, not necessarily many, members)	Integrate coastal hazards and climate change in surf life saving training programs
North Kirra	Operation	Quantity of trained staff	Having sufficient trained members (number of beachgoers)	Promote training programs within the community
		Effective equipment	Appropriate equipment (number of beachgoers)	Identify possible innovations in equipment
SLSA	Mainstreaming climate change	Mainstream climate change	Attitude (core business)	Mainstreaming climate adaptation into operations
	Club capacity building	Partnerships	Networks communication (membership base)	Improve communication with clubs
	Partnership	Relationships/connections (sufficient funding, effective personnel and effective organisation)	Relationships/connections (sufficient funding, effective personnel and effective organisation)	Build relationships with national organisations (insurance companies, federal and state bodies, etc.)

4. DISCUSSION

4.1 *Methodological approach and outcomes*

This section presents a discussion on each stage and component of the research.

4.1.1 Stakeholder engagement

Stakeholder engagement was a key issue in carrying out the whole project. Relevant elements to be considered are:

1. Motivational reasons to get stakeholders involved (rewards?)
2. Shifting pool of stakeholders: stakeholders and people in roles can change over time; availability of people is often limited
3. Diversity of stakeholder groups: some case study areas had more representation from the club members, others also had representatives from the local community and government
4. Limited capacity of people to interact online: people sometimes have limited access or will to access electronic media (emails, surveys, social networks, spreadsheets).

The survey conducted was useful to gather insight about the opinions of stakeholders on climate change and adaptation processes. The use of the survey instrument to explore social networks had limited success, but it was effective to test a social networks approach for engagement, which can be used for future projects.

4.1.2 System conceptualisation and Structural Analysis

The system conceptualisation exercise during the workshop had some limitations, mainly related to the fact that workshop participants were not trained to think in complexity and systems. It was relatively easy to identify issues, but connections were harder to identify. The work done by stakeholders was integrated by the project team using MICMAC as a platform to consolidate the list of variables, including a test of adaptive responses. These were integrated by other variables based on the expert knowledge within the team and tested against all the other variables through an iterative, matrix-building approach. The MICMAC approach is limited compared to VENSIM as it describes the level of influence but does not distinguish between positive and negative influence. In this sense, we are currently considering integrating MICMAC with a more complete approach based on System Dynamics notation (Sterman 2000), which was tested in a different project in Egypt and which is currently in review (Sanò et al. 2013 in review). This future integration would be a great venue for improving software capabilities and migrating the system to an online platform.

The resulting conceptual models created with MICMAC are relatively hard to interpret; however, the system allows analysts to reduce the number of variables and connections (not shown in this report). The tables illustrating direct influence/dependence, based on Godet (2006) and generated with MICMAC are better suited to understand the role of each variable. The final evaluation of the variables in terms of their influence on the system proved to be very useful in identifying which adaptive responses were more suitable for testing using a Bayesian approach.

4.1.3 System Dynamics modelling

At the time of writing we are not able to provide a discussion on the System Dynamics modelling process, which was not a contractual deliverable of this project. However, details will be provided in a separate publication, currently in preparation. We will integrate his discussion at a later stage before the end of the project.

4.1.4 Bayesian modelling

The sensitivity analysis provides a formal process for testing the relative sensitivities of the different variables on each adaptation option. However, further information provided in the discussions that accompany the development of these networks can further contextualise the importance of different variables. For example, while *Future Requirements* (Ulverstone workshop – *Retreat* adaptation option) ranked much lower in the sensitivity analysis compared to the other primary-level variables, there was interesting discussion about this particular variable during the model-building process. Specifically, it was intently discussed that *Retreat* is not necessarily a process of simply shifting the current building inland. Rather, the context for evaluating and exploring the efficacy of carrying out this adaptation option should also acknowledge the possibility that the future requirements of the SLSC might be different from current requirements and that this potential change could impact on the retreat process.

Some of the BBNs, or at least sub-components of BBNs, highlighted divergence between the stakeholders with respect to their expertise or background, and such differences can manifest in the probabilities that are assigned during the CPT-populating process. For example, the two stakeholders involved in exploring the *retreat* adaptation option during the Cudgen Headland workshop had different experiences and associations within the SLSC.

Funding emerged as a common issue for the seven BBNs that were developed by the clubs involved. Typically (but not always), funding was directly linked to the adaptation option, although there were instances where it had an indirect affect. For example, for North Kirra, funding emerged as an important determinant of maintaining effective operations at both the primary and secondary levels. Two of the clubs (Cudgen Headland and Ulverstone) identified that the adaptation options were more dependent on external sources of funding (government grants, council rate base) than internal sources. Conversely, North Kirra perceived that internal revenue raised from pokies, membership fees and restaurant takings were much more influential.

For the asset protection adaptation options (retreat and defend), common themes of stakeholder and community support emerged for both the Cudgen Headland and Ulverstone workshops (asset protection adaptation options were not tested at the North Kirra workshop). For example, the success of relocation at Cudgen Headland was linked to the ability to maintain a ‘connection’ with the community, while for Ulverstone, community support was perceived as an important part of generating the impetus that was required to retreat.

The importance of effective training and sufficient staff emerged from the three BNs that were developed around maintaining effective operations as an adaptation option. The importance of having appropriate equipment (i.e. assets) was raised by Ulverstone and North Kirra stakeholders in their respective BNs. Both acknowledged that funding was an important, if not the most important, determinant for this. Ulverstone perceived that the appropriateness (or effectiveness) of the equipment was also dependent on its design (technology) and training of members (to use the equipment). The stakeholders from North Kirra considered the appropriateness of the equipment would be influenced

by the amount of beachgoers and the framework that was in place within the club to inspect/maintain/update equipment. All three BNs raised the influence or importance of members in providing effective operations although the emphasis was slightly different. Cudgen (amenities and existing culture) and North Kirra (equipment) highlighted factors that were likely to attract membership while Ulverstone were more explicit about the importance of experience in producing effective members.

The BBN for SLSA is contextually different from those developed for the three SLSCs because climate change adaptation is about governance and policy development (rather than asset protection and service provision to beachgoers at a specific beachside location). The adaptation options that were selected by the stakeholders were mainstreaming climate change, SLSA capacity (and whether it was sufficient) and maintaining effective partnerships (between SLSA and the clubs and sponsors). Among these three adaptation options, common themes of knowledge (about climate change), networks with the stakeholders (partners, SLSCs) and whether the SLSA operations were core business (or not) emerged. Conversely, funding only emerged as a determinant once (SLSA capacity).

4.2 Systems Thinking and modelling for climate change adaptation

This research project demonstrated the applicability of Systems Thinking and modelling approaches, in particular Bayesian modelling, to climate change adaptation in coastal areas. Using Australian surf life saving as a case study, we demonstrated that the combination of stakeholder-based techniques can be effective in exploring mental models of stakeholders and identifying adaptive responses and the enablers and constraints of the adaptive capacity for implementation. In particular, we showed that Systems Thinking and modelling techniques are not designed to solve problems, but rather are tools to navigate complexity and focus on the core of problems. The information produced with this approach – including the map of existing stakeholders, the conceptual model of the relationships between drivers, impacts and responses, the System Dynamics model for scenario simulations or the Bayesian tree of adaptive capacity determinants – can be practically used to support decisions and indirectly employed to foster dialogue and create consensus within stakeholders groups. From a practical perspective, the research allowed the identification of a set of ten actions to enhance adaptive capacity of SLSA in facing coastal hazards and climate change. These are discussed in the next section.

4.3 Addressing research objectives: identify and enhance the adaptive capacity of Surf Life Saving Australia

The objectives of the research, as reported in section 1.2, were designed around the use of systems approaches, in particular Systems Thinking and Bayesian modelling, in exploring the adaptive capacity of SLSA, using selected surf clubs and the national coordinating body as case studies. This approach was previously used to address adaptive capacity at the regional level in South East Queensland, under the SEQCARI project (CSIRO 2011). By strongly relying on stakeholder engagement, the process went through the identification of adaptive responses using systems conceptualisation techniques. These were then further explored, using Bayesian modelling techniques, to identify the enablers and constraints of adaptive capacity, which were then prioritised using sensitivity testing capabilities of Bayesian modelling. In practice, we found that rather than identifying adaptive capacity determinants, it would be more appropriate to use this approach to explore the existing enablers and constraints for adaptive capacity and use this information to identify actions that improve adaptive capacity.

The outcome of this analysis, reported in Table 19, shows a range of actions to enhance adaptive capacity, both at the club level and at the SLSA level. Ten actions, with an indication of the responsibility for their implementation, were synthesised from those of Table 19:

<u>1. Create mechanisms to access coastal-hazards funding sources.</u> A range of mechanisms to access funding are already in place for SLSA and SLSCs, which rely on money and in-kind support from a range of public and private organisations. However, clubs at risk should start looking into partnerships with government and the private sector to manage their assets and operations in the future. From an SLSA perspective, creating a coastal-hazard program and fund could be an option for ad hoc interventions for clubs in need.

<u>2. Provide access to alternative equipment to keep operations at the beach.</u> Surf life saving should look at more flexible options to provide water safety services, by looking into a model that works independently from the existence of a clubhouse. This may include both movable equipment and other options to store and move equipment independently from the clubhouse. In addition, this equipment should be able to work effectively with different beach and accessibility conditions.

<u>3. Improve fundraising mechanisms at the club level</u>. The existing fundraising mechanisms should be improved by looking at new ways to raise funds from both club members, clubhouse users, government and the private sector. Fundraising professionals should be consulted for this purpose.

<u>4. Provide information to the community about existing adaptation options</u>. The community should be given access to information on options to adapt to coastal hazards and climate change, including which type of coastal defence and building designs are available to manage erosion and inundation and mechanisms to implement a planned retreat if no other option is feasible.

<u>5. Integrate coastal hazards and climate change in surf life saving training programs.</u> Surf life saving training programs are focusing on water safety; however, information on beach and coastal processes (e.g. climate change and wave climate, rip currents, etc.) can raise awareness and understanding about the coastal system and create a favourable culture to identify and adopt innovative approaches for surf life saving operations in the future.

<u>6. Promote training programs within local coastal communities.</u> SLSCs may choose to adopt the role of training provider for coastal communities by integrating coastal-hazard education in their existing training for different ages and introducing new programs.

<u>7. Identify possible innovations in equipment.</u> Equipment shortages and risks under a changing climate should be considered at the club level. New flexible equipment should be identified and, in certain cases, gradually replace existing. The risk posed by coastal hazards should be considered in this process.

<u>8. Mainstreaming climate adaptation into national operations</u>. Climate change should be considered as a possible element that can influence how SLSA will carry out operations in the future. Mainstreaming adaptation may include actions for improving the capacity of the national body to respond to the risks posed by coastal hazards and climate change, by, for instance, promoting the distribution of climate-wise information to the clubs, providing information on possible insurance options for clubs, and integrating climate change into training programs promoted at the national level.

9. Improve communication with clubs. Clubs should be informed of the risks posed by climate change and of possible options to tackle the problem. This may include factsheets or online tools to support club decisions. These should consider differences in legislation and policies between Australian states.

10. Build relationships with national organisations dealing with coastal hazards and climate change. SLSA should connect with national organisations dealing with coastal hazards and climate change. For instance, SLSA may decide to sit on the Coastal Council, a federal body, as observer; or join the Australian Coastal Society. In addition, it may build connections with national-level insurance organisations, such as the Insurance Council of Australia.

5. CONCLUSIONS

This project ABFlags started from the need of SLSA to look at detailed climate change–related issues for the national organisation and local clubs. In this context, the Systems Thinking and modelling approaches employed in the project were demonstrated to be useful to engage stakeholders and researchers in identifying adaptation options and adaptive capacity determinants for their implementation. Systems Thinking and modelling approaches, such as those employed here (SNA, Structural Analysis, System Dynamics and Bayesian Modelling) are able to create a close representation of reality, based on stakeholders' mental constructs. In practice, they can only provide a direction for the implementation of specific actions, which, in most cases, will require more specific studies, such as coastal processes and engineering, or equipment design. These limitations are implicit to the method, which does not aim to find the exact alternative solution to a problem but rather focus on possible pathways and sets of actions which can be taken to adapt to climatic challenges now and in the future.

In particular, in our study we showed how these methods were able to:

1. Collect information and involve relevant people for stakeholder-driven processes
2. Collect data from stakeholders and use these data for a range of purposes, including for more detailed in-house modelling using a range of systems techniques
3. Identify adaptation options and the enablers and constraints (the adaptive capacity determinants) to implement these options
4. Create a set of actions designed to improve the adaptive capacity of SLSA.

Involving stakeholders in identifying information needs has a range of additional benefits, as the process can be used to communicate with stakeholders on potential adaptation pathways (e.g. defend, retreat, accommodate) or build trust, consensus and understanding within communities.

In this way, the research project reached its objective of identifying the adaptive capacity determinants of SLSA, using a range of case studies, both at the local scale (clubs) and national scale (SLSA). In addition, a model for enhancing adaptive capacity was proposed by selecting a set of ten priority actions to be used for improving adaptive capacity in the future:

1. Create mechanisms to access coastal-hazards funding sources
2. Provide access to alternative equipment to keep operations at the beach
3. Improve fundraising mechanisms at the club level
4. Provide information to the community about existing adaptation options
5. Integrate coastal hazards and climate change in surf life saving training programs
6. Promote training programs within local coastal communities
7. Identify possible innovations in equipment
8. Mainstream climate adaptation into national operations
9. Improve communication with clubs
10. Build relationships with national organisations dealing with coastal hazards and climate change.

6. OUTPUTS, GAPS AND FUTURE RESEARCH DIRECTIONS

6.1 Research outputs

Current research outputs include research papers, conference presentations and end-user products.

6.1.1 Research papers

1. Sanò, M., Richards, R., Sahin, O., Ware, D., Sherker, S., and Tomlinson, R. 'Adapting Australian surf life saving assets and operations to coastal hazards and climate change' (Synthesis paper, in preparation)
2. Sahin, O., Richards, R., and Sanò, M. 'Modelling adaptation scenarios with System Dynamics. The Case of Surf Life Saving Australia' (in preparation)
3. Ware, D., Sanò, M., and Sherker, S. 'Stakeholder engagement for adaptation planning of life saving assets and operations' (in preparation)
4. Richards, R., Sanò, M., and Sahin, O. 'Exploring climate change adaptive capacity of Surf Life Saving using Bayesian belief networks' (in preparation).

6.1.2 Conference presentations

Below is a list of conference presentation fully or partially using materials from this project:

1. Sanò, M., Richards, R., Sahin, O. and Mackey, B. 2013. Systems Thinking and Modelling for Coastal Zone Management and Climate Change Adaptation. MODSIM2013. *International Conference on Modelling and Simulation*, Adelaide, 1–6 December.
2. Sahin, O., Richards, R., and Sanò, M. 2013. Integrated Modelling Approach for Climate Change Adaptation: The Case of Surf Life Saving Australia. MODSIM2013. *International Conference on Modelling and Simulation*, Adelaide, 1–6 December.
3. Sherker, S., Farmer, N., Richards, R., Sahin, O., Sanò, M., Ware, D., Tomlinson, R. Adapt between the flags: Enhancing the capacity of Surf Life Saving Australia to cope with climate change. *Climate Adaptation 2013: Knowledge + Partnerships* Sydney, 24–27 June.
4. Richards, R., Sanò, M., Sahin, O. and Tiller, R. The (uncertain) world according to Bayes: Bayesian belief networks and the triple bottom line in the context of climate change. *ISA Annual Convention 2013*, San Francisco, 3–6 April.
5. Sanò, M. 2012. Approaches in Stakeholder Identification and Engagement in Coastal Zone Management and Climate Change *Adaptation. Australian Climate Change Adaptation Research Network for Settlements and Infrastructure. 8th Early Career Researchers National Forum and Workshop*. Gold Coast 26–28 November.
6. Ware, D., Raybould, M., Sanò, M., Anning, D. and Lazarow, N. 2012. Surfing media mix for climate adaptation research on the beach. *Australian and New Zealand Conference Society for Ecological Economics 2012 Conference*, Bond University, Gold Coast 12–15 November.
7. Sanò, M. 2012. Adapting Coasts to Climatic Futures. Australian Climate Change Adaptation Research Network for Settlements and Infrastructure. *7th Early Career Researchers National Forum and Workshop*. Melbourne, 7–9 May.
8. Sherker, S., Brighton, B., Sanò, M., Richards, R., Sahin, O., Ware, D., Tomlinson, R. and Farmer, N. 2012. Adapt Between The Flags – Enhancing the

capacity of Surf Life Saving to cope with extreme weather and climate change. *Australia Water Safety Conference 2012*, Sydney, 4–5 June.
9. Farmer, N., Elrick, C., Kay, R., Sanò, M. and Sherker, S. 2012. Adaptation of Coastal and Beach Safety Services in a Changing Climate. *2012 National Climate Adaptation Conference*, Melbourne, 26–28 June [Poster].
10. Sahin, O., Richards, R., Sanò, M. and Sherker, S. 2012. Modelling Climate Change Adaptation Pathways with System Dynamics. The Case of Surf Life Saving Australia. *25th European Conference on Operational Research*, Vilnius, Lithuania, 8–11 July.
11. Ware, D., Sanò, M. and Sherker, S. 2012. Social Network Analysis for adaptation planning of Surf Life Saving Clubs. *Coast to Coast 2012*, Brisbane, 17–21 September.

6.1.3 End-user products

The following end-user products will be delivered to SLSA as part of this project:

1. End-user–friendly summary of case study outcomes
2. Factsheets on coastal hazards and adaptation options relevant at the national level.

6.1.4 Public outreach

1. Mendeley Science page: http://www.mendeley.com/groups/2105363/adapt-between-the-flags/
2. Facebook page for stakeholders: https://www.facebook.com/pages/Adapt-Between-the-Flags/135531283244184

6.2 Research limitations and gaps

Research limitations of this project included:

1. Limited number of case studies: with more than 300 clubs around Australia, we were able to look at only 1% of these with the existing resources
2. Limited capacity to engage stakeholders: stakeholders involved in the project were often hard to engage as some of them had limited technical knowledge, lack of understanding of research methods or, in some cases, were biased by climate change scepticism
3. Need for improved integration between models and approaches: the used approaches are complementary; however, the flow of data use between them can sometimes be unclear and subject to interpretation by different researchers.

Future research in this field may focus on filling these gaps:

1. Increase the number of case studies, possibly by also using online tools for data collection
2. Apply the method to other organisations or case studies, for instance emergency services, medical facilities or military operations
3. Use the outcomes of the research to implement specific actions to enhance adaptive capacity of Surf Life Saving Australia.

6.3 *Future research*

Currently Griffith University has supported its partnership with SLSA by providing additional funds under the GU Industry Collaborative Scheme. This will be the base to expand the research activities to additional case study areas in South Australia and Western Australia in 2013. These funds will also be used to set the basis for a future project under the ARC Linkage program to be submitted in September 2013. A one-day workshop was carried out on 11 April 2013 to set out the scope of future project activities stemming from the outcomes of current research, to inform the following:

1. Extend the research to other clubs at risk from climate change, including clubs in South Australia and Western Australia (project funded under the GU Industry Collaborative Scheme partnership)
2. Validate and extend the survey to other clubs across the country to understand risks of climate change and map social relevance to clubs.

It is anticipated that the second research project under the ARC, if approved, may include activities related to:

1. Variability and change of extreme storms, operations and assets management
2. Role of SLSA in coastal community resilience
3. Training and capacity building in coastal hazard management for clubs.

Detailed research priorities will be identified with SLSA in the coming months.

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APPENDIX 1: SURVEY ON CLIMATE CHANGE AND SOCIAL NETWORKS

Q1.1 What is your full name? (this is optional and will only be available to the research team but will greatly assist in analysing the data)

Q1.2 Did you participate in the workshop on climate change adaptation hosted by Griffith University and SLSA earlier this year?

- ❍ No (1)
- ❍ Yes - Cudgen (2)
- ❍ Yes - Currumbin (3)
- ❍ Yes - Ulverstone (4)
- ❍ Yes - SLSA National Office (5)

Q1.3 Are you a Surf Life Saving Club Member?

- ❍ No (1)
- ❍ Yes - Cudgen (2)
- ❍ Yes - Currumbin (3)
- ❍ Yes - Ulverstone (4)
- ❍ Yes - Other (Please specify below) (5) ____________________

Q1.4 Other than Surf Life Saving do you hold a role (professional or voluntary) or membership of any organisations/groups with an interest in coastal management?

	ORGANISATION/GROUP (1)	ROLE (2)	TERM (NUMBER OF YEARS IN ROLE) (3)
1 (1)			
2 (2)			
3 (3)			
4 (4)			
5 (5)			
6 (6)			

Q1.1.2 Have you been invited to attend the SLSA National Office Workshop?

- ❍ Yes (1)
- ❍ No (2)

If Yes Is Selected, Then Skip To End of Block

Q2.1 Of the following surf life saving clubs which one are you in closest proximity to?

- ❍ Cudgen - Kingscliff NSW (1)
- ❍ Currumbin - Gold Coast QLD (2)
- ❍ Ulverstone - TAS (3)

Q3.1 Section 2 - This is the second of four pages of the survey and includes three questions about climate change and beach and foreshore management and recreation.

Q3.2 From what you know about climate change which of the following statements comes closest to your opinion?

- ❍ Climate change has been established as a serious problem requiring immediate action (1)
- ❍ There is enough evidence that climate change is taking place and some action should be taken (2)
- ❍ We don't know enough about climate change and more research is necessary before we take any action (3)
- ❍ Concern about climate change is unwarranted (4)
- ❍ No opinion, I don't know (5)
- ❍ Other (please describe) (6) ____________________

Q3.3 If sea levels were to rise and/or erosion and flooding risks increase which of the following statements comes closest to your opinion?

- ❍ Move infrastructure and housing to safer locations protected from rising waters (1)
- ❍ Use engineered structures to protect infrastructure and housing from rising waters (2)
- ❍ Use a combination of design, new materials and changed behaviour to accommodate rising waters (3)
- ❍ No opinion, I don't know (4)
- ❍ Other (please describe) (5) ____________________

Q3.4 In your opinion what are the main issues for beach and foreshore recreation and safety associated with climate change?

	HIGH PRIORITY (1)	PRIORITY (2)	LOW PRIORITY (3)	NOT AN ISSUE (4)
Physical exposure (sea level rise, storm surge, shoreline loss, erosion) (1)	❍	❍	❍	❍
Potential development in vulnerable locations (2)	❍	❍	❍	❍
Loss of foreshores and recreation areas (3)	❍	❍	❍	❍
Impact on existing public infrastructure (4)	❍	❍	❍	❍
Legal liability for governments in planning decisions (5)	❍	❍	❍	❍
Impact on existing private homes (6)	❍	❍	❍	❍
Capacity of emergency response systems (7)	❍	❍	❍	❍
Economic impacts on tourism sector (8)	❍	❍	❍	❍
Increased population (9)	❍	❍	❍	❍
Lifestyle impacts (natural amenity, climate) (10)	❍	❍	❍	❍
Other (please describe) (11)	❍	❍	❍	❍

Q3.5 Other than coastal hazards and climate change - what are the key issues for beach and foreshore recreation and safety in your local area?

Q4.1 Section 3 - This is the third of four pages of the survey and includes one question about the organisations and people you are in contact with regarding Coastal Management. Coastal Management refers to the activities by governments and communities to coordinate and control the use and development of the coastline with implications for beach users, local residents, tourists, commerce and nature. This question is highly important to the overall research project so please take the time to respond. (Any personal details provided will only be used to distribute an invitation to participate in this survey and will not be kept, shared or used for any other purposes.)

Q4.3 Based on your experience please list the people and organisations you feel are most important to coastal management at Ulverstone. In the matrix below please list the person's name, related organisation/group name and classify your relationship with them. Where there is an important organisation like the local council but you do not know the name of a representative leave the name and email columns blank and fill in the organisation and relationship columns (Please answer as many as you like)

	ORGANISATION/COMPANY/GROUP (PLEASE LIST THOSE RELEVANT TO COASTAL MANAGEMENT. COULD BE AS AN EMPLOYEE OR AS MEMBER/VOLUNTEER FOR COMMUNITY GROUPS) (3)	EMAIL ADDRESS (OPTIONAL) (1)	ON A SCALE OF 0-3 RATE YOUR RELATIONSHIP WHERE 0 = NO RELATIONSHIP AND 3 = STRONG RELATIONSHIP (2)
Insert person's name below (1)			
Insert person's name below (2)			
Insert person's name below (3)			
Insert person's name below (4)			
Insert person's name below (5)			
Insert person's name below (6)			
Insert person's name below (7)			
Insert person's name below (8)			
Insert person's name below (9)			
Insert person's name below (10)			

Q107 Section 3 - This is the third of four pages of the survey and includes one question about the organisations and people you are in contact with regarding Coastal Management. Coastal Management refers to the activities by governments and communities to coordinate and control the use and development of the coastline with implications for beach users, local residents, tourists, commerce and nature. This question is highly important to the overall research project so please take the time to respond. (Any personal details provided will only be used to distribute an invitation to participate in this survey and will not be kept, shared or used for any other purposes.)

Q108 Based on your experience please list the people and organisations you feel are most important to coastal management at Currumbin. In the matrix below please list the person's name, related organisation/group name and classify your relationship with them. Where there is an important organisation like the local council but you do not know the name of a representative leave the name and email column blank and fill in the organisation and relationship columns (Please answer as many as you like)

	ORGANISATION/COMPANY/GROUP (PLEASE LIST THOSE RELEVANT TO COASTAL MANAGEMENT. COULD BE AS AN EMPLOYEE OR AS MEMBER/VOLUNTEER FOR COMMUNITY GROUPS) (3)	EMAIL ADDRESS (OPTIONAL) (1)	ON A SCALE OF 0-3 RATE YOUR RELATIONSHIP WHERE 0 = NO RELATIONSHIP AND 3 = STRONG RELATIONSHIP (2)
Insert person's name below (1)			
Insert person's name below (2)			
Insert person's name below (3)			
Insert person's name below (4)			
Insert person's name below (5)			
Insert person's name below (6)			
Insert person's name below (7)			
Insert person's name below (8)			
Insert person's name below (9)			
Insert person's name below (10)			

Q109 Section 3 - This is the third of four pages of the survey and includes one question about the organisations and people you are in contact with regarding Coastal Management. Coastal Management refers to the activities by governments and communities to coordinate and control the use and development of the coastline with implications for beach users, local residents, tourists, commerce and nature. This question is highly important to the overall research project so please take the time to respond. (Any personal details provided will only be used to distribute an invitation to participate in this survey and will not be kept, shared or used for any other purposes.)

Q110 Based on your experience please list the people and organisations you feel are most important to coastal management at Kingscliff. In the matrix below please list the person's name, related organisation/group name and classify your relationship with them. Where there is an important organisation like the local council but you do not know the name of a representative leave the name and email columns blank and fill in the organisation and relationship columns (Please answer as many as you like)

	ORGANISATION/COMPANY/GROUP (PLEASE LIST THOSE RELEVANT TO COASTAL MANAGEMENT. COULD BE AS AN EMPLOYEE OR AS MEMBER/VOLUNTEER FOR COMMUNITY GROUPS) (3)	EMAIL ADDRESS (OPTIONAL) (1)	ON A SCALE OF 0-3 RATE YOUR RELATIONSHIP WHERE 0 = NO RELATIONSHIP AND 3 = STRONG RELATIONSHIP (2)
Insert person's name below (1)			
Insert person's name below (2)			
Insert person's name below (3)			
Insert person's name below (4)			
Insert person's name below (5)			
Insert person's name below (6)			
Insert person's name below (7)			
Insert person's name below (8)			
Insert person's name below (9)			
Insert person's name below (10)			

Q113 Section 3 - This is the third of four pages of the survey and includes one question about the organisations and people you are in contact with regarding Coastal Management. Coastal Management refers to the activities by governments and communities to coordinate and control the use and development of the coastline with implications for beach users, local residents, tourists, commerce and nature. This question is highly important to the overall research project so please take the time to respond. (Any personal details provided will only be used to distribute an invitation to participate in this survey and will not be kept, shared or used for any other purposes.)

Q114 Based on your experience please list the people and organisations you feel are most important to coastal management for SLSA as a national organisation. In the matrix below please list the person's name, related organisation/group name and classify your relationship with them. Where there is an important organisation like the local council but you do not know the name of a representative leave the name and email columns blank and fill in the organisation and relationship columns (Please answer as many as you like)

	ORGANISATION/COMPANY/GROUP (PLEASE LIST THOSE RELEVANT TO COASTAL MANAGEMENT. COULD BE AS AN EMPLOYEE OR AS MEMBER/VOLUNTEER FOR COMMUNITY GROUPS) (3)	EMAIL ADDRESS (OPTIONAL) (1)	ON A SCALE OF 0-3 RATE YOUR RELATIONSHIP WHERE 0 = NO RELATIONSHIP AND 3 = STRONG RELATIONSHIP (2)
Insert person's name below (1)			
Insert person's name below (2)			
Insert person's name below (3)			
Insert person's name below (4)			
Insert person's name below (5)			
Insert person's name below (6)			
Insert person's name below (7)			
Insert person's name below (8)			
Insert person's name below (9)			
Insert person's name below (10)			

Q7.1 Section 4 - This is the final page of the survey and includes basic demographic details about you.

Q7.2 Please answer the following questions about yourself

YOUR AGE (1)	HIGHEST LEVEL OF EDUCATION COMPLETED (2)	CURRENT JOB OR EMPLOYMENT STATUS (RETIRED / UNEMPLOYED / STUDENT) (3)	NUMBER OF YEARS LIVING IN THIS AREA (4)
18 to 25 (1)	Primary (1)	Full Time (1)	>1 (1)
26 to 30 (2)	Secondary (2)	Part Time (2)	1–2 (2)
31 to 40 (3)	Trade (3)	Casual (3)	2–5 (3)
41 to 50 (4)	Bachelor Degree (4)	Student (4)	5–10 (4)
51 to 60 (5)	Postgraduate (5)	Retired (5)	10–15 (5)
61 to 70 (6)	Other (6)	Unemployed (6)	15–20 (6)
70-80 (7)	. (7)	Other (7)	21–30 (7)
>80 (8)	. (8)	. (8)	>30 (8)

Q7.3 Are there any final comments you wish to make regarding any of the issues raised in this survey?

Q7.4 If you are open to further contact regarding this research project please include contact details below?

Q8.1 Section 4 - This is the final page of the survey and includes basic demographic details about you.

Q8.2 Do you have formal role/position with the Surf Life Saving Club you are a member of?

Q8.3 Please answer the following questions about yourself

YOUR AGE (1)	18–25	26–30	31–40	41–50	51–60	61–70	70–80	>80
HIGHEST LEVEL OF EDUCATION COMPLETED (2)	Primary	Secondary	Trade	Bachelor	Postgrad.	Other		
CURRENT JOB OR EMPLOYMENT STATUS (RETIRED/UNEMPLOYED/ STUDENT) (3)	Full Time	Part Time	Casual	Student	Retired	Unemployed	Other	
NUMBER OF YEARS LIVING IN THIS AREA (4)	>1	1–2	2–5	5–10	10–15	15–20	21–30	>30
NUMBER OF YEARS THAT YOU HAVE BEEN A MEMBER OF YOUR CURRENT CLUB (5)	>1	1–2	2–5	5–10	10–20	20–30	30–40	>40
NUMBER OF YEARS THAT YOU HAVE BEEN INVOLVED WITH SURF LIFE SAVING (6)	>1	1–2	2–5	5–10	10–20	20–30	30–40	>40

Q8.4 Are there any final comments you wish to make regarding any of the issues raised in this survey?

Q8.5 If you are open to further contact regarding this research project please include contact details below?

APPENDIX 2: SYSTEM DYNAMICS MODELS DOCUMENTATION

Variables sorted by name

MODEL INFORMATION	NUMBER
Total Number of Variables	52
Total Number of State Variables (Level+Smooth+Delay Variables)	7
Total Number of Stocks (Stocks in Level Sm ooth De lay a riables) †	7
Time Unit	Year
Initial Time	0
Final Time	50
Time Step	1
Model Is Fully Formulated	Yes
Modeler-Defined Groups	- N o -
VPM File Available	- N o -

Variable types

L : Level (7 / 7)*	SM: Smooth (0 / 0)*	DE : Delay (0 / 0) * †	LI : Level Initial (0)
I : Initial (0)	C : Constant (11)	F: Flow (12)	A : Auxiliary (34)
Sub :Subscripts(0)	D : Data (0)	G : Game (0)	T: Lookup (1 / 1) ††

* (state variables / total stocks)

** Feature not yet implemented

† Total stocks do not include fixed delay variables

†† (lookup variables / lookup tables)

TYPE	VARIABLE NAME AND DESCRIPTION
A	Accessibility (Dmnl) = (Air+Sea +Rail+Road)/4 Present in 1 view: Operation Used by: Local Visitor Tourists
C	AdaptationInvestment (Dmnl [0,1,1]) = 1 Present in 2 views: Output Graphs Operation Used by: Club Revenue Air Road Sea Rail
F, A	Added Roads (Dmnl) = (1-Annual Storm Event Frequency/365)* Roads Present in 1 view: Operation Used by: Roads
A	Air (Dmnl) = IF THEN ELSE(Adaptation Investment>=1, 1, (1-Annual Storm Event Frequency/365)) Present in 1 view: Operation Used by: Accessibility
F,A	Airport Conditions (Dmnl) = Airports Present in 1 view: Operation Used by: Airports
L	Airports (Dmnl) = $\int$ (Increased Air Capacity-Airport Conditions) dt + [1] Present in 1 view: Operation Used by: Airport Conditions Increased Air Capacity

TYPE	VARIABLE NAME AND DESCRIPTION
A	Annual Storm Event Frequency (Dmnl) = Initial StormEvent Frequency* (CARI/FARI) Description: Calculated using = Initial StormEvent Frequency*(Current ARI/Future ARI) Current ARI: The average, or expected, value of the periods between exceedances of a given storm event over a given duration. Using the logarithmic equation above , it is calculated based on various SS Heights (e.g. current ARI would be 10, 50 and 100 for 1.6 m, 2.26 and 2.55 mm SS Height respectively) Present in 3 views: Operation ClimateChange Community Used by: SLS Training Condition Patrols Added Roads Air Capacity Increase Increased Air Capacity Road Sea Rail Increased railway capacity Growth rate Beach Safety Index Beach Closure Duration
F,A	Bad Road Conditions (Dmnl) = Roads Present in 1 view: Operation Used by: Roads
A	Beach Closure Duration (Day) = Annual Storm Event Frequency*Recovery time Description: Beach closure is the function of Storm Events. It is assumed that beach will be closed during the storm events and will be reopened after a few days depending on the recovery rate. The number of days beach closure over a year is calculated based on storm events and average duration of beach closure Present in 2 views: Operation Community Used by: Club Revenue Customer In BeachGoers

TYPE	VARIABLE NAME AND DESCRIPTION
C	Beach Closure Impacts on Revenue (Dmnl [0,1,0.1]) = 0.5 Description: This index is used to calculate the impact of beach closure on club customers and beachgoers. It is assumed that, during the beach closure, number of customers will be reduced by 20%. Thus, if beach closure is 1 Day. The impact can be reduced with adaptation. Present in 2 views: Output Graphs Operation Used by: Club Revenue
A	Beach Safety Index (Dmnl) = 100-Annual Storm Event Frequency*Patrols Description: During the storm the beach safety can't be maintained due to minimised or ceased patrolling and increase danger from the extreme conditions Present in 1 view: ClimateChange Used by: This is a supplementary variable.
A	BeachGoers (people) = Tourists*0.35+Population*0.1-((Tourists*0.35+Population*0.1)*Beach Closure Duration/365) Description: Beachgoers is assumed to be proportional to total population within the club catchment and number of tourist visiting the region, and directly related to the storm/extreme events as beach/club assumed to be closed during the event. Assuming that beachgoers equal to zero during the beach closure, by subtracting closed days from the total figure we may capture the changes in beachgoers Present in 1 view: Community
F,A	Capacity Decrease (Dmnl) = Ports Facilities Present in 1 view: Operation Used by: Ports Facilities
F,A	Capacity Increase (Dmnl) = (1-Annual Storm Event Frequency/365)* Ports Facilities Present in 1 view: Operation Used by: Ports Facilities
A	CARI (Dmnl) = EXP((Height of 100 y Event-0.6594)/ Slope) Present in 1 view: ClimateChange Used by: Annual Storm Event Frequency

TYPE	VARIABLE NAME AND DESCRIPTION
L	Club Customers (percent) = $\int$ (Customer In-Customer Out) dt + [100] Present in 1 view: Operation Used by: Club Revenue Customer Out Customer In
A	Club Members (Dmnl) = Population*0.01 Present in 1 view: Operation Used by: Club Revenue
A	Club Revenue (percent) = IF THEN ELSE(Adaptation Investment>=1, (Club Members*0.1+Club Customers*0.9-(Club Customers*0.9*0.5*Beach Closure Impacts on Revenue*Beach Closure Duration/365)), (Club Members*0.1+Club Customers*0.9-(Club Customers*0.9*Beach Closure Impacts on Revenue*Beach Closure Duration/365))) Description: It is assumed that the club revenue consist of (10%) membership fee and (90%) customers It is also assumed that, during the beach closure, number of customers will be reduced by 20%. Thus, if beach closure is 1 Day, the decrease in the number of customer will be equal to 10% of total customers per day (revenue from clubcustomers less revenue from clubcustomers* Beach closure index/365) as beach closure unit is set as Day. It is also assumed that, investment in adaptation would reduce the negative impact by 50%. To calculate this, weight of beach closure index reduced by the same amount 50% Present in 1 view: Operation Used by: Employment
F,A	Customer In (Dmnl) = (Local Visitor+Tourists)*Club Customers*(1-Beach Closure Duration/365) Present in 1 view: Operation Used by: Club Customers
F,A	Customer Out (Dmnl) = Club Customers Present in 1 view: Operation Used by: Club Customers

TYPE	VARIABLE NAME AND DESCRIPTION
C	Economy (Dmnl [0,1,1]) = 1 Description: this variable is controlled by a slider. 1 indicates a positive economy an 0 negative Present in 1 view: Operation Used by: Local Visitor Tourists
T,A	Employment (Dmnl) = WITH LOOKUP (Club Revenue,([(0,0)-(150,200)],(0,0),(30,25),(50,55),(60,65),(70,79),(80,88), (90,95),(100,100),(150,120))) Present in 1 view: Operation Used by: This is a supplementary variable
A	FARI (meter) = EXP((Height of 100 y Event-(0.6594+Sea Level))/ Slope) Present in 1 view: ClimateChange Used by: Annual Storm Event Frequency
C	FINAL TIME (Year) = 50 Description: The final time for the simulation Not present in any view
A	Growth rate (percent) = IF THEN ELSE(Annual Storm Event Frequency<=1.5, 0.0028, IF THEN ELSE(Annual Storm Event Frequency>1.5 :AND:Annual Storm Event Frequency<=2, 0.015, IF THEN ELSE(Annual Storm Event Frequency>2 :AND:Annual Storm Event Frequency<=2.5, 0.008, IF THEN ELSE(Annual Storm Event Frequency >2.5 :AND:Annual Storm Event Frequency<=3, - 0.001,IF THEN ELSE(Annual Storm Event Frequency>3 :AND:Annual Storm Event Frequency<=3.5, - 0.01, -0.02))))) Description: the current growth rate in the region is currently 2.8% for GC and will be controlled with a slider If the Annual Storm Event Frequency is 1.5 or less, growth = 2.8%,If the Annual Storm Event Frequency is between 2 and 2.5, growth = 0.008%,If the Annual Storm Event Frequency is between 3 and 3.5, growth = -0.01%, Present in 2 views: Operation Community Used by: Local Visitor Tourists Pop Increase

TYPE	VARIABLE NAME AND DESCRIPTION
C	Height of 100 Year Event (meter) = 2.54 Description: Height of 100 year storm surge even in Moreton Bay = 2.54 m Present in 1 view: ClimateChange Used by: CARI FARI
F,A	Increase (meter/Year) = Rise rate Present in 1 view: ClimateChange Used by: Sea Level
F,A	Increased Air Capacity (Dmnl) = (1-Annual Storm Event Frequency/365)*Airports Present in 1 view: Operation Used by: Airports
F,A	Increased railway capacity (Dmnl) = (1-Annual Storm Event Frequency/365)*Railway Description: It is assumed that railway will be disrupted when storm events occurred. As the storm frequency increases the disruption will increase proportionately, for example, if currently, railway disrupted once a year, linear increase will be observed as storm frequency increases Present in 1 view: Operation Used by: Railway
C	Initial Storm Event Frequency (Dmnl) = 1.5 Description: The maximum tidal range is 1.8m and on average the gold coast region is affected by 1.5 cyclones each year Present in 2 views: Output Graphs ClimateChange Used by: SLS Training Condition Annual Storm Event Frequency
C	INITIAL TIME (Year) = 0 Description: The initial time for the simulation. Not present in any view Used by: Time

TYPE	VARIABLE NAME AND DESCRIPTION
A	Local Visitor (percent) = IF THEN ELSE(Economy>=1, (0.5 *(1+Growth rate)*Accessibility), (0.5 *(1+Growth rate)*Accessibility)*0.9) Description: It is assumed that 50% of the club customers are local, and changed based on economy, accessibility and growth rate. if the economy and accessibility are not good then local visitor will decrease by 10 % of previous year Present in 1 view: Operation Used by: Customer In
A	Membership (Dmnl) = INTEGER(Population*0.01) Description: membership is assumed to be proportional to total population within the club catchment (e.g. 0.01) Present in 2 views: ClimateChange Community Used by: This is a supplementary variable
A	Patrols (Dmnl) = SLS Training Condition/Annual Storm Event Frequency Description: During the storm event, beach closed and beach patrol activities stop / minimised. As storm event frequency increases, the patrolling activities decreases as a result of cascading effects, less safe beach, deteriorating training conditions Present in 1 view: ClimateChange Used by: Beach Safety Index
F,A	Pop Increase (percent) = Growth rate*Population Present in 1 view: Community Used by: Population

TYPE	VARIABLE NAME AND DESCRIPTION
L	Population (percent) $= \int$ (Pop Increase) dt + [100] Description: In the 2011 Census the population of Currumbin is 2,785 and is comprised of 49.1% males and 50.9% females. Together with the surroundings assumed to be 10000. Present in 2 views: Operation Community Used by: Club Members BeachGoers Membership Volunteers Pop Increase
L	Ports Facilities (Dmnl) $= \int$ (Capacity Increase-Capacity Decrease) dt + [1] Present in 1 view: Operation Used by: Capacity Decrease Capacity Increase
A	Rail (Dmnl) = IF THEN ELSE(Adaptation Investment>=1, 1, (1-Annual Storm Event Frequency/365)) Present in 1 view: Operation Used by: Accessibility
F,A	Rail Capacity Decrease (Dmnl) = Railway Present in 1 view: Operation Used by: Railway
L	Railway (Dmnl) $= \int$ (Increased railway capacity-Rail Capacity Decrease) dt + [1] Present in 1 view: Operation Used by: Rail Capacity Decrease Increased railway capacity

TYPE	VARIABLE NAME AND DESCRIPTION
C	Recovery time (Day [0,30,3]) = 1 Description: Time required to recover major extreme event (e.g. 3 days, 1 week, etc) Present in 1 view: Operation Used by: Beach Closure Duration
C	Rise rate (meter/Year [0,0.02,0.001]) = 0.01 Description: 1 cm/year sea level rise controlled by a slider to change the rate of sea level rise Present in 1 view: ClimateChange Used by: Increase
A	Road (Dmnl) = IF THEN ELSE(Adaptation Investment>=1, 1, (1-Annual Storm Event Frequency/365)) Present in 1 view: Operation Used by: Accessibility
L	Roads (Dmnl) = $\int$ (Added Roads-Bad Road Conditions) dt + [1] Present in 1 view: Operation Used by: Added Roads Bad Road Conditions
A	Sea (Dmnl) = IF THEN ELSE(Adaptation Investment>=1, 1, (1-Annual Storm Event Frequency/365)) Present in 1 view: Operation Used by: Accessibility
L	Sea Level (meter) = $\int$ (Increase) dt + [0] Present in 1 view: ClimateChange Used by: FARI

TYPE	VARIABLE NAME AND DESCRIPTION
C	Slope (Dmnl) = 0.4094 Description: Slope of the line for Exp function to calculate future ARI (X) or height (Y)using (Y=0.4094*Ln(X)+0.6594) Present in 1 view: ClimateChange Used by : CARI FARI
A	SLS Training Condition (Dmnl) = (Initial StormEvent Frequency/Annual Storm Event Frequency)*100 Present in 1 view: ClimateChange Used by : Patrols
C	TIME STEP (Year [0,?]) = 1 Description: The time step for the simulation. Present in 1 view: ClimateChange Used by: SAVEPER - The frequency with which output is stored.
A	Tourists (percent) = IF THEN ELSE(Economy>=1, (0.5 *(1+Growth rate)*Accessibility), (0.5 *(1+Growth rate)*Accessibility)*0.9) Description: if economy and accessibility good 50% customer from tourist if not, 10% decrease based on previous year Present in 2 views: Operation Community Used by: Customer In BeachGoers
A	Volunteers (Dmnl) = INTEGER(Population*0.005) Description: number of volunteers is assumed to be proportional to total population within the club catchment (e.g. 0.005) Present in 1 view: Community Used by: This is a supplementary variable

Level Structure †

Airports = $\int$ (IncreasedAirCapacity-AirportConditions) dt + [1] Airport Conditions = Airports
Increased Air Capacity = (1-AnnualStormEventFrequency/365)*Airports

Club Customers = $\int$ (CustomerIn-CustomerOut) dt + [100]
Customer In = (LocalVisitor+Tourists)*Club Customers*(1-BeachClosureDuration/365) Customer Out = Club Customers

Population = $\int$ (PopIncrease) dt + [100] Pop Increase = Growthrate*Population

Ports Facilities = $\int$ (CapacityIncrease-Capacity Decrease) dt + [1] Capacity Decrease = PortsFacilities
Capacity Increase = (1-AnnualStormEventFrequency/365)* PortsFacilities

Railway = $\int$ (Increasedrailwaycapacity-RailCapacityDecrease) dt + [1]
Increased railway capacity = (1-AnnualStormEventFrequency/365)*Railway Rail Capacity Decrease = Railway

Roads = $\int$ (AddedRoads-BadRoadConditions) dt + [1]
Added Roads = (1-AnnualStormEventFrequency/365)*Roads
Bad Road Conditions = Roads

Sea Level = $\int$ (Increase) dt + [0] Increase = Riserate

APPENDIX 3: BAYESIAN BELIEF MODELS

ULVERSTONE 2nd WORKSHOP

GROUP 1 (DEFEND) – OS facilitator

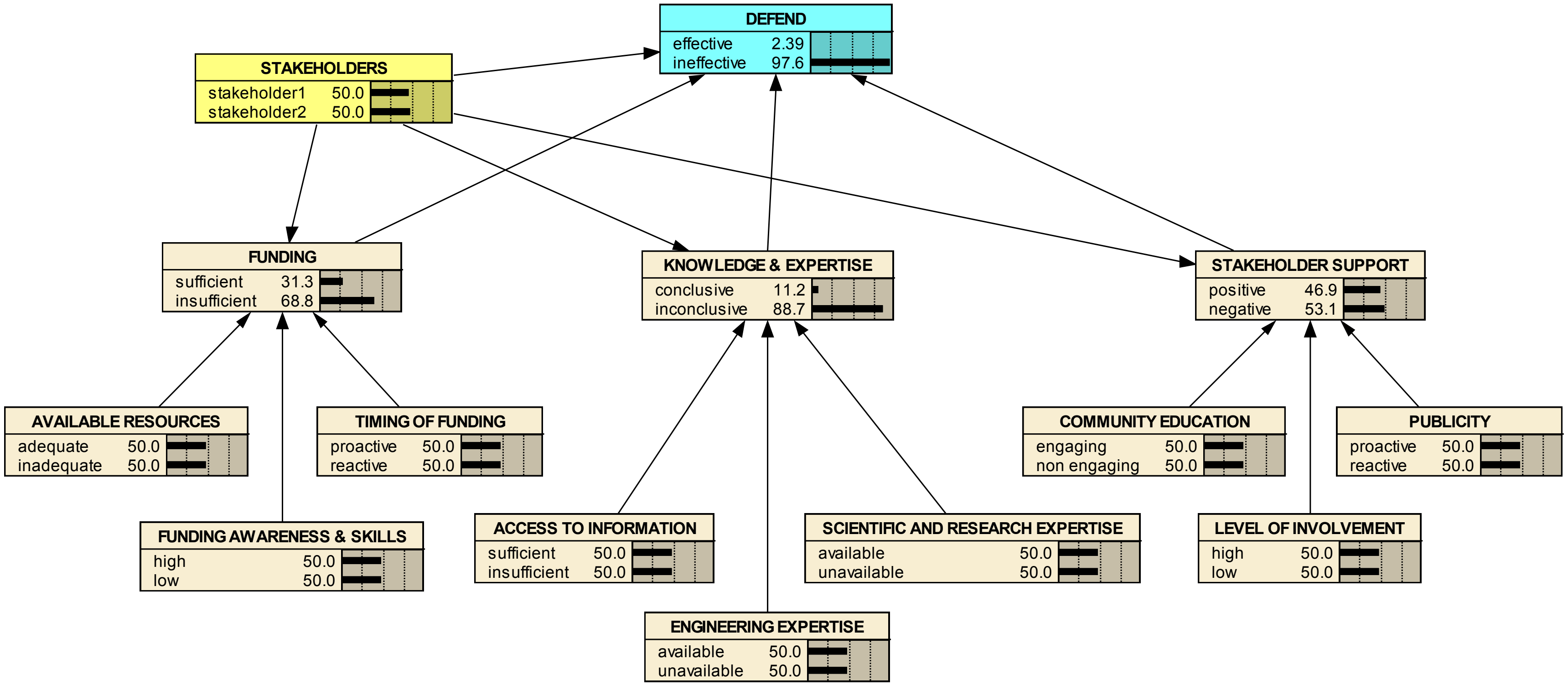

Figure A3.1: Compiled BBN for adaptation option 'Defend'

Table A3.1: Sensitivity of ‘Defend’ to a finding at another node

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEFS
Defend	0.16254	100	0.0232814
Knowledge_Expertise	0.07870	48.4	0.0044874
Funding	0.04096	25.2	0.0012514
Access_to_info	0.02427	14.9	0.0005688
Engineering_expertis	0.02427	14.9	0.0005688
Scientific_Research_	0.02427	14.9	0.0005688
Funding_Awareness	0.01133	6.97	0.0003251
Available_Resources	0.01017	6.26	0.0002958
Timing_of_funding	0.00083	0.509	0.0000265
Stakeholder_Support	0.00047	0.289	0.0000152
Stakeholders	0.00011	0.0703	0.0000037
Publicity	0.00004	0.0223	0.0000012
Level_of_Involvement	0.00002	0.00962	0.0000005
Community_Education	0.00001	0.00771	0.0000004

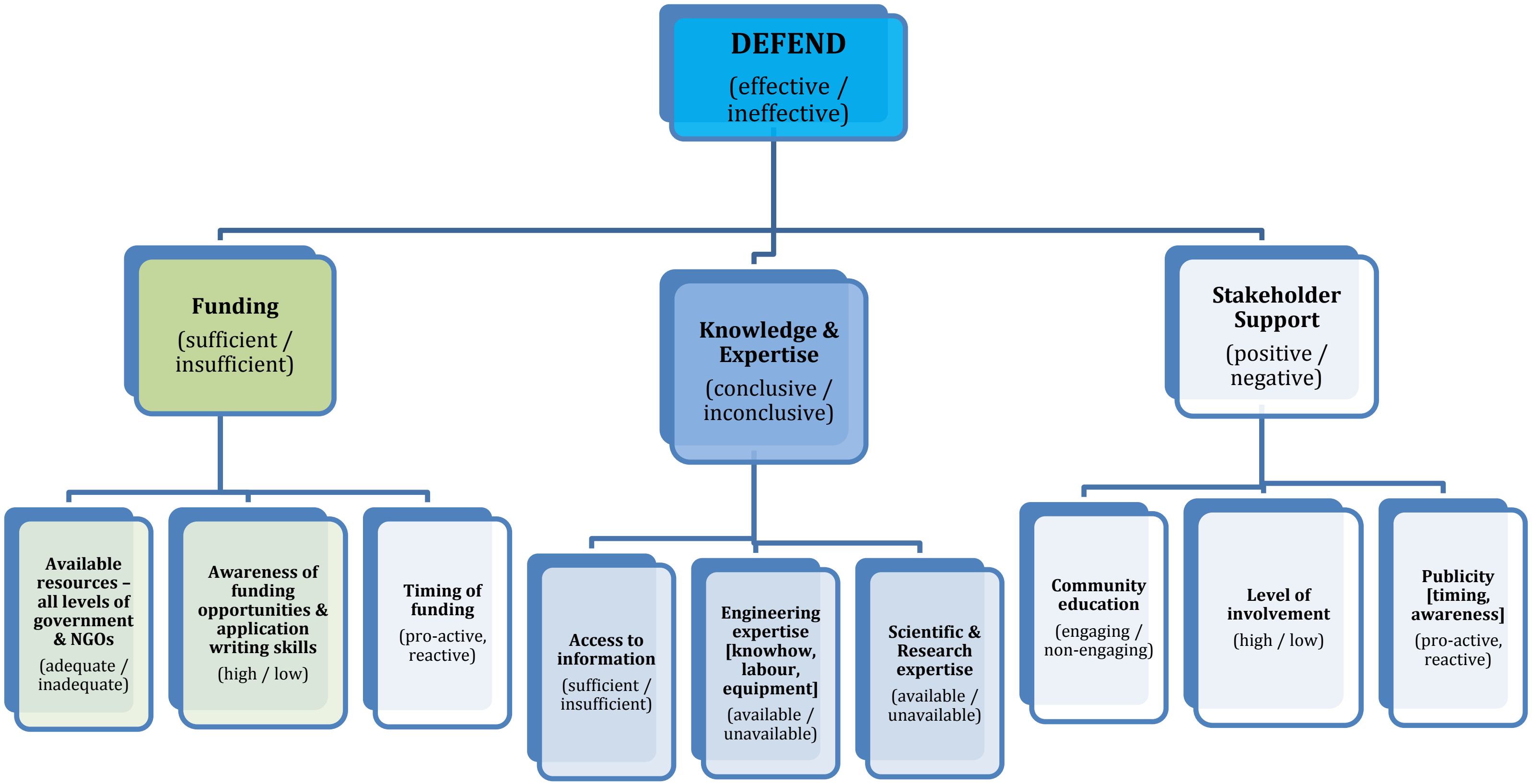

Figure A3.2: Ulverstone 'Defend' sensitivity pathways

- Note: blue is most sensitive, green is second highest
- Note that there are only two stakeholders involved in the conditional probabilities (5 stakeholders involved in developing the BBN structure)
- The three secondary variables 'acting' on *Knowledge & Expertise* have equal weighting

GROUP 2 (WATER SAFETY OPERATIONS) – MS facilitator

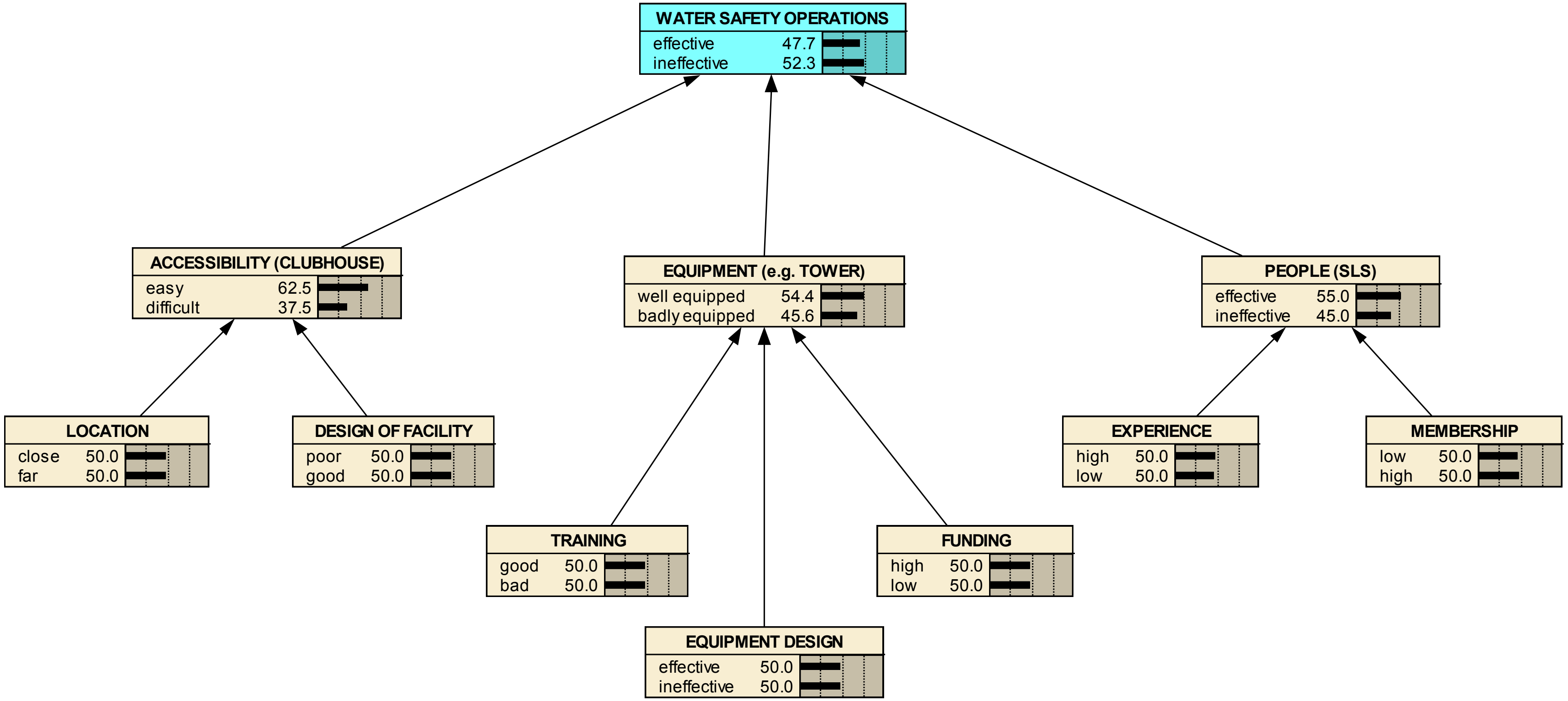

Figure A3.3: Compiled BBN for adaptation option 'Water safety operations'

Table A3.2: Sensitivity of 'Water Safety Operations' to a finding at another node

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEFS
Water_safety_Operation	0.99844	100	0.2494588
People	0.29316	29.4	0.0933136
Experience	0.10050	10.1	0.0339322
Membership	0.02467	2.47	0.0084831
Accessibility	0.02234	2.24	0.0076532
Equipment	0.01957	1.96	0.0067286
Design_of_facility	0.00715	0.716	0.0024694
Training	0.00466	0.467	0.0016114
Locations	0.00289	0.29	0.0010000
Equipment_Design	0.00111	0.111	0.0003825
Funding	0.00052	0.0519	0.0001790

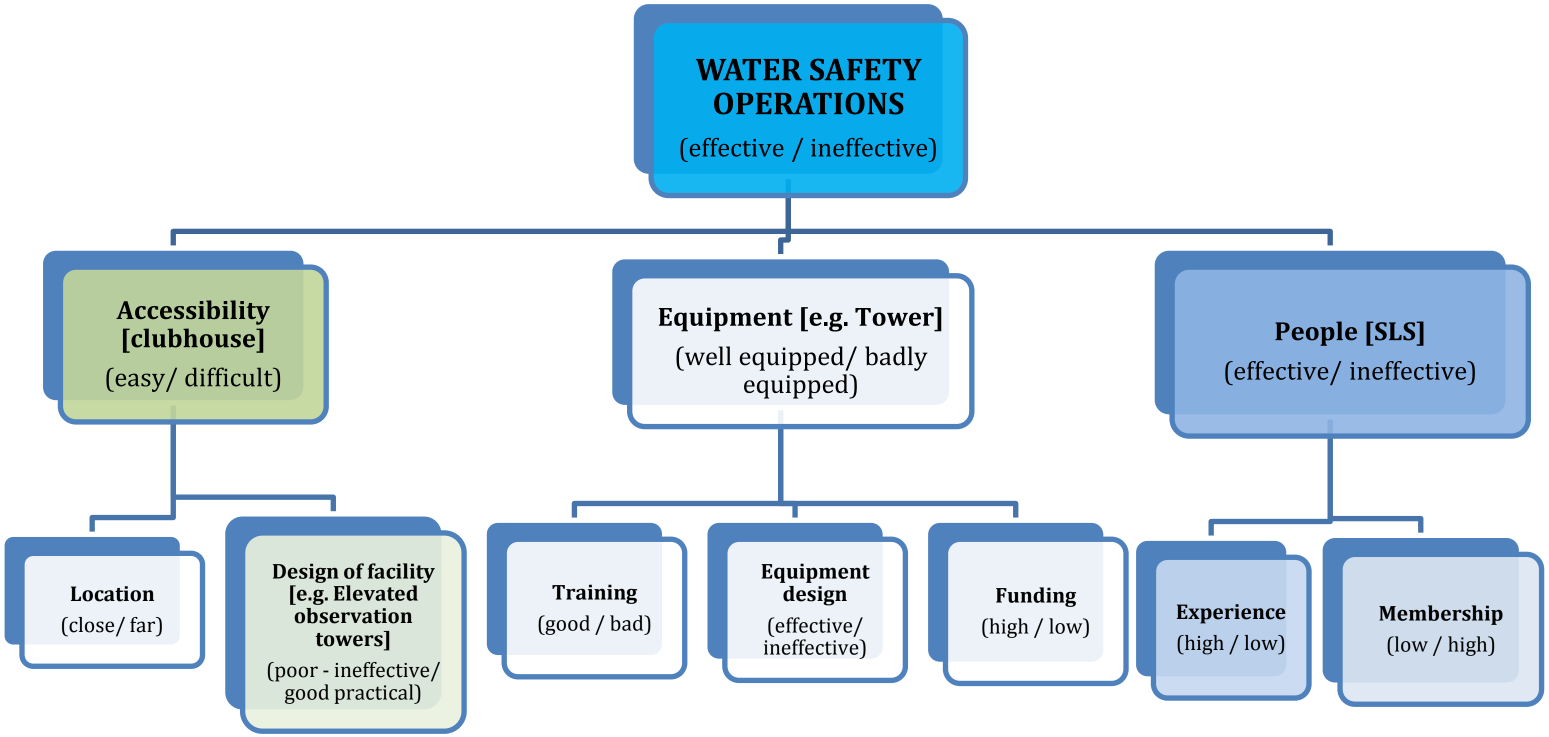

Figure A3.4: Ulverstone 'Water safety operations' sensitivity pathways

- Note: blue is most sensitive, green is second highest
- Note that two stakeholders were involved in the development of the BBN structure and combined to create a single set of conditional probabilities for the BBN – thus there is no auxiliary variable representing the stakeholder effect.
- The primary level variable *People* is clearly the most influential variable here. In turn, it is almost equally dependent on *Experience* and *Membership* (secondary-level variables).
- *Accessibility* (clubhouse) is the second most influential variable at the primary level of the BBN; however, it should be noted that (a) this is much less influential than *People*, and (b) it is only slightly more influential than *Equipment*. At the secondary level, the *Design of the facility* is influential, but the context is that *Accessibility* itself is not particularly influential.

GROUP 3 (RETREAT) – RR facilitator

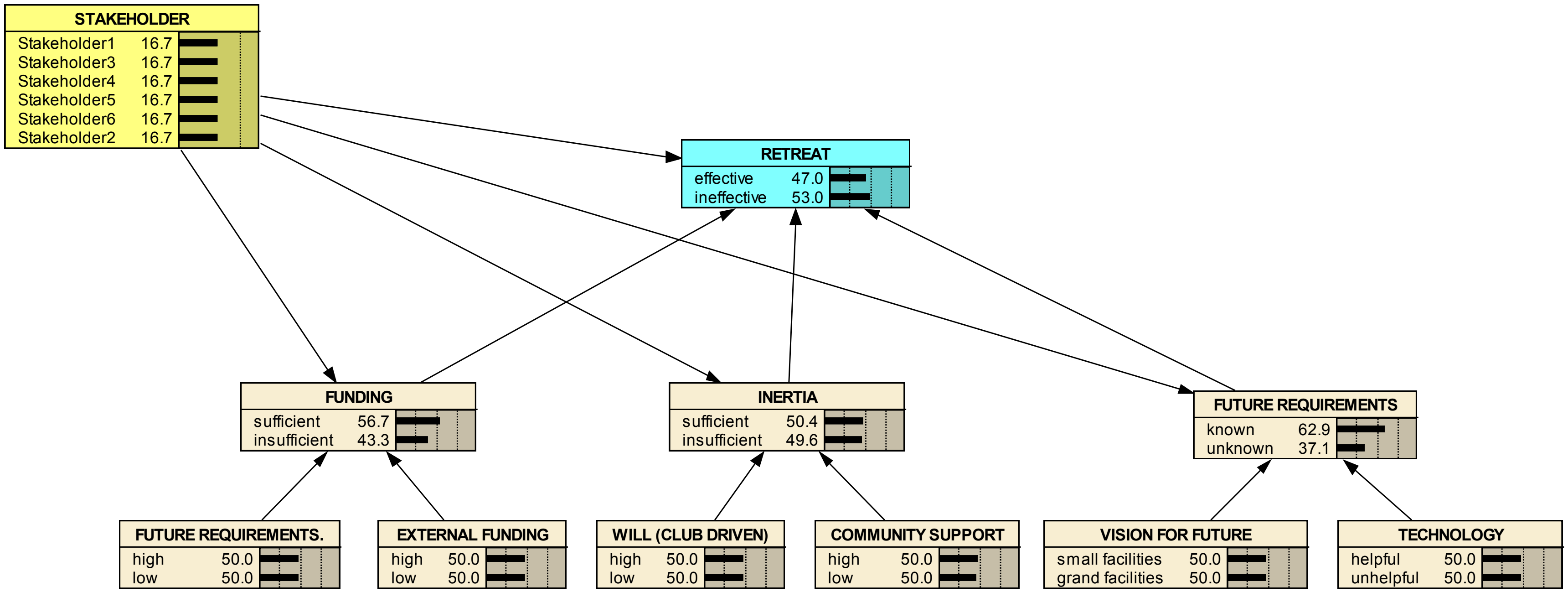

Figure A3:5: Compiled BBN for adaptation option 'Retreat'

Table A3.3: Sensitivity of 'Retreat' to a finding at another node

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEFS
Retreat	0.99746	100	0.2491219
Inertia	0.14927	15	0.0497010
Funding	0.12621	12.7	0.0419606
External_Funding	0.05817	5.83	0.0198154
Stakeholder	0.05109	5.12	0.0172551
Will_club	0.03580	3.59	0.0122590
Future_Requirements	0.03424	3.43	0.0116471
Community_Support	0.02374	2.38	0.0081542
Technology	0.00870	0.872	0.0029992
Future_Requirements	20.00613	0.615	0.0021144
Future_Vision	0.00423	0.424	0.0014598

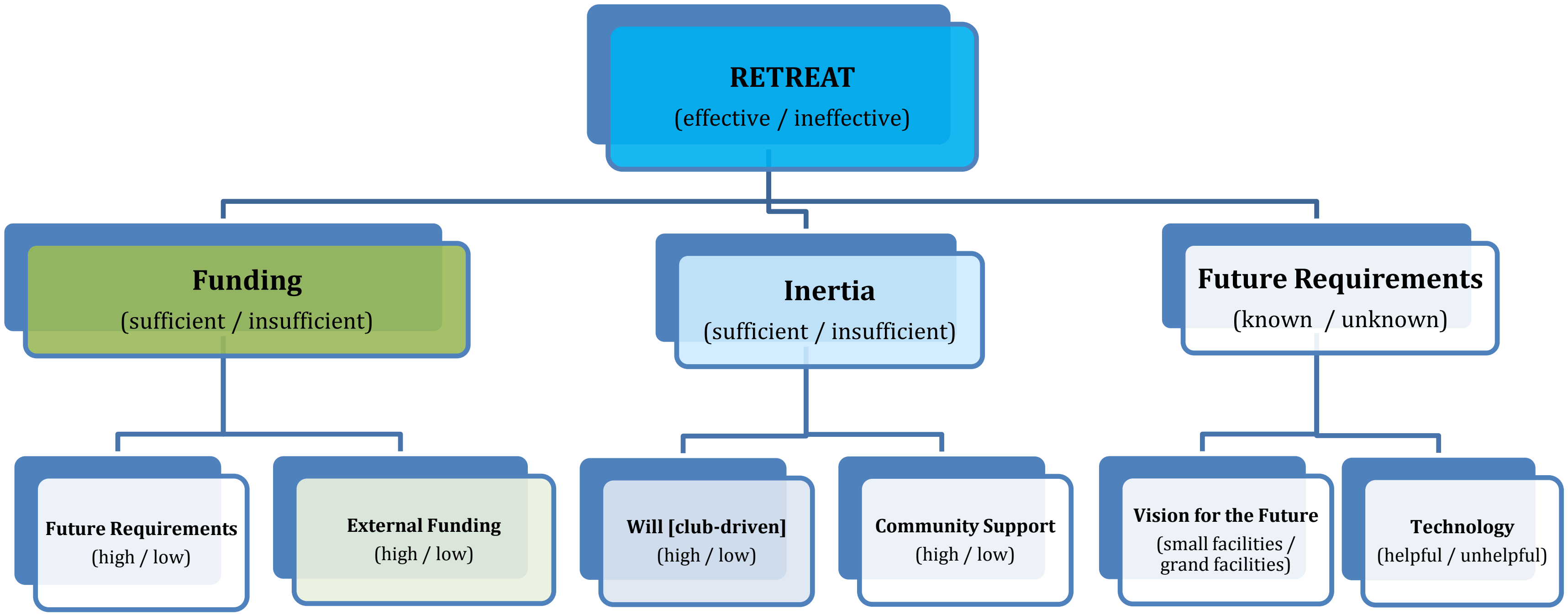

Figure A3.6: Ulverstone 'Retreat' sensitivity pathways

- Note: blue is most sensitive, green is second highest
- All six stakeholders involved in both the BBN structure and conditional probability tables
- *Inertia* slightly more influential than *Funding* (acting upon RETREAT)
- *External Funding* is seen as important (e.g. more influential than *Future Requirements* [primary variable])
- The variable *Stakeholders*, which represents the effect that the individual beliefs of the stakeholders converge (or diverge) is mid-table in the sensitivity analysis. This indicates that there is a fair amount of agreement in their beliefs and what they consider to be important variables
- While *Future Requirements* (primary level) ranks low in the sensitivity analysis, there was good discussion about this during the BBN construction. Specifically, *Retreat* is not necessarily a process of shifting the building inland – there was acknowledgement that future operations might not need to be the same as current operations

KINGSCLIFF 2nd WORKSHOP

Group 1 (Facilitator: Russell)

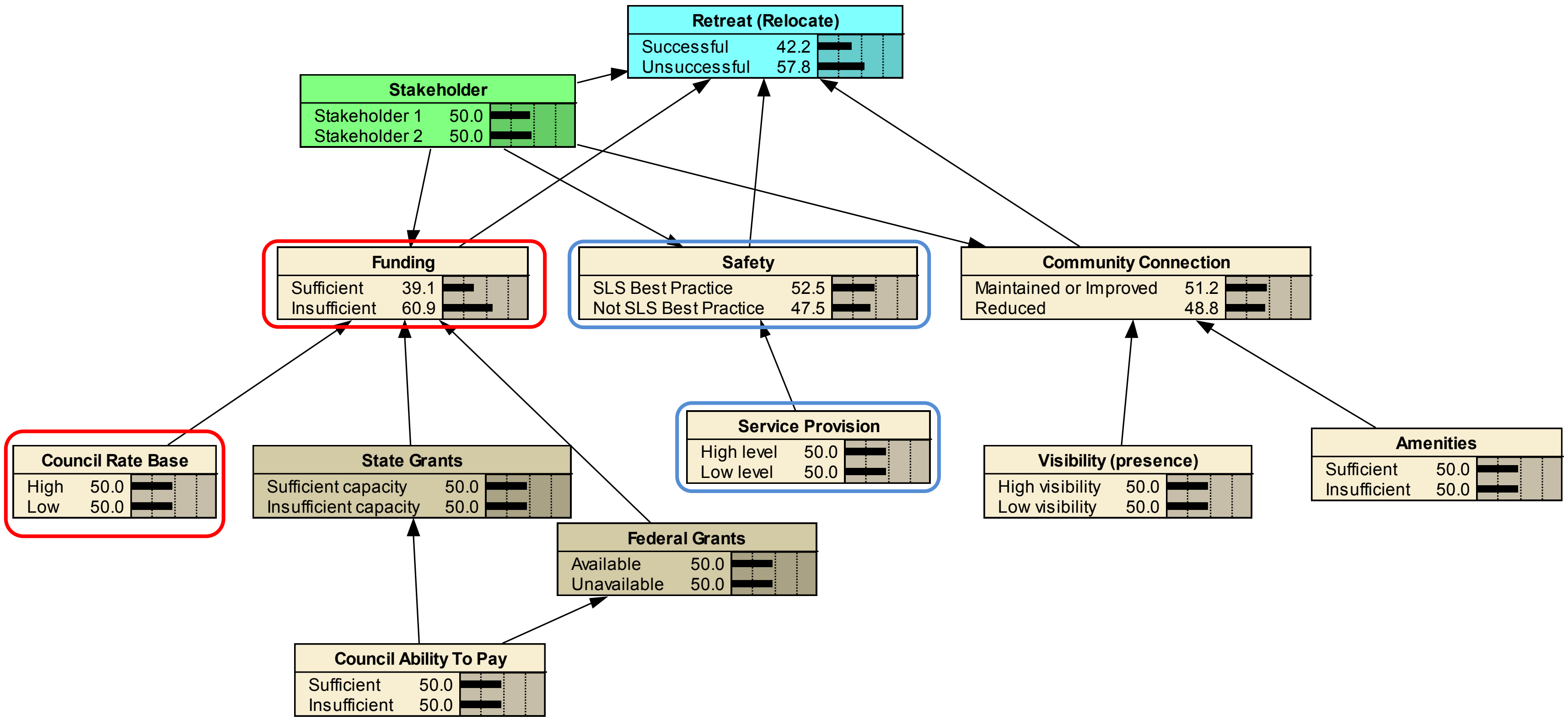

Figure A3.7: BBN developed around 'Retreat (Relocate)'

Variables highlighted by red rectangles highlight most influential path (on SLS operations), blue indicates second most influential path.
note that the two variables in beige ('State Grants' and 'Federal Grants') are treated as deterministic nodes rather than probabilistic (chance) nodes because the CPT for these nodes is 100% if 'Council Ability to Pay' 100% and 0% if 'Council Ability to Pay' 0%.
the auxiliary node (Stakeholder) is not linked to 'State Grants' and 'Federal Grants' because stakeholder 1 did not provide these probabilities.

Table A3.4: Sensitivity analysis (based upon 'Retreat (Relocate)'

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEF
Retreat_Relocate	0.98254	100	0.2439730
Funding	0.24247	24.7	0.0784345
Council_Rate_Base	0.11975	12.2	0.0392450
Safety	0.02610	2.66	0.0087494
Service_Provision	0.02309	2.35	0.0077628
Stakeholder	*0.02205*	*2.24*	*0.0074143*
Council_ability_to_pay	0.02032	2.07	0.0068357
Federal_Grants	0.02032	2.07	0.0068357
State_Grants	0.02032	2.07	0.0068357
Community_Connection	0.01417	1.44	0.0047723
Amenities	0.00330	0.336	0.0011158
Visibility_and_presence	0.00090	0.0911	0.0003028

Sensitivity analysis synopsis: The most influential variable on the priority issue is 'Funding' – this is clearly the dominant consideration based on the beliefs of these two stakeholders. Just as clear is the role of 'Council Rate Base' as the funding stream.

'Safety' of swimmers is the next most influential and this is dependent on the capacity of the SLSC to provide this safety.

The auxiliary Stakeholder node is mid-ranked in terms of the influence that it has on the priority issue indicating that the beliefs of the two stakeholders are convergent.

Group 2 (Facilitator: Oz)

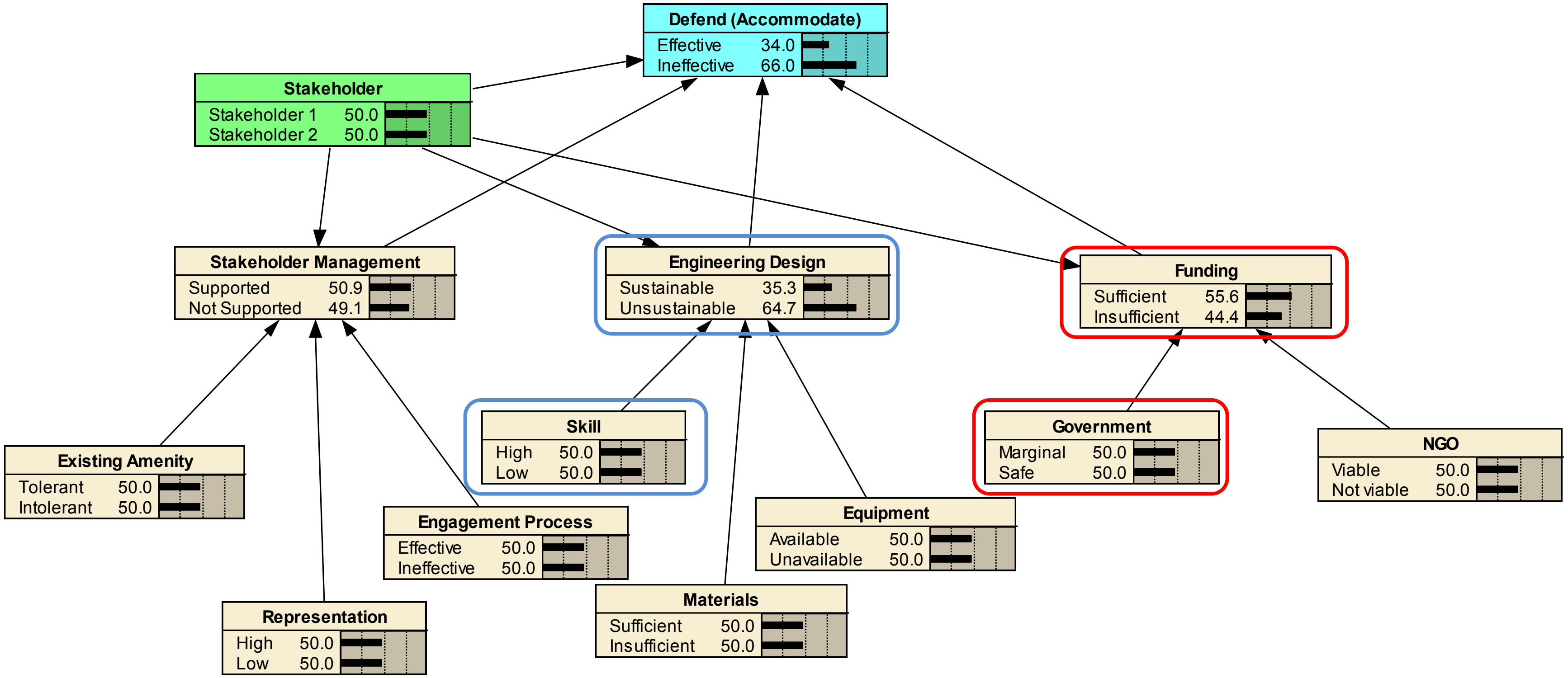

Figure A3.8: BBN developed around 'Defend (Accommodation)'

Variables highlighted by red rectangles highlight most influential path (on SLS operations), blue indicates second most influential path.

Table A3.5: Sensitivity analysis (based upon ‘Defend (Accommodation)’

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEFS
Defend_Accommodate	0.92454	100	0.2243074
Funding	0.15226	16.5	0.0433920
Government	0.08644	9.35	0.0260739
Stakeholder	*0.04152*	*4.49*	*0.0127264*
Engineering_Design	0.03734	4.04	0.0118026
Stakeholder_Manageme	0.02752	2.98	0.0084626
Skill	0.00637	0.689	0.0019760
Existing_Amenity	0.00517	0.559	0.0016049
NGO	0.00501	0.542	0.0015548
Materials	0.00399	0.432	0.0012405
Representation	0.00207	0.224	0.0006429
Engagement_Process	0.00171	0.185	0.0005312
Equipment	0.00094	0.102	0.0002936

Sensitivity analysis synopsis: The most influential variable acting on the priority issue is ‘Funding’ – this is clearly the key issue in this BBN – so much so that the next most influential variable acting on the priority issue is ‘Government’, which is a parent node for ‘Funding’. Thus, based on the beliefs of these stakeholders, effective Defence (Accommodation) is strongly dependent on whether Government is ‘safe’ (desirable) or ‘marginal’ (undesirable).

‘Engineering Design’ and ‘Stakeholder Management’ have similar influence (which is much less than ‘Funding’).

The variable ‘Stakeholder’ is relatively influential, which indicates some divergence on the probabilities assigned by the two stakeholders. However, this does not necessarily mean that the two stakeholders have diverging beliefs; they might have similar beliefs about the relative importance of the different variables and thus the divergence simply reflects different probabilities assigned by them.

Group 3 (Facilitator: Marcello)

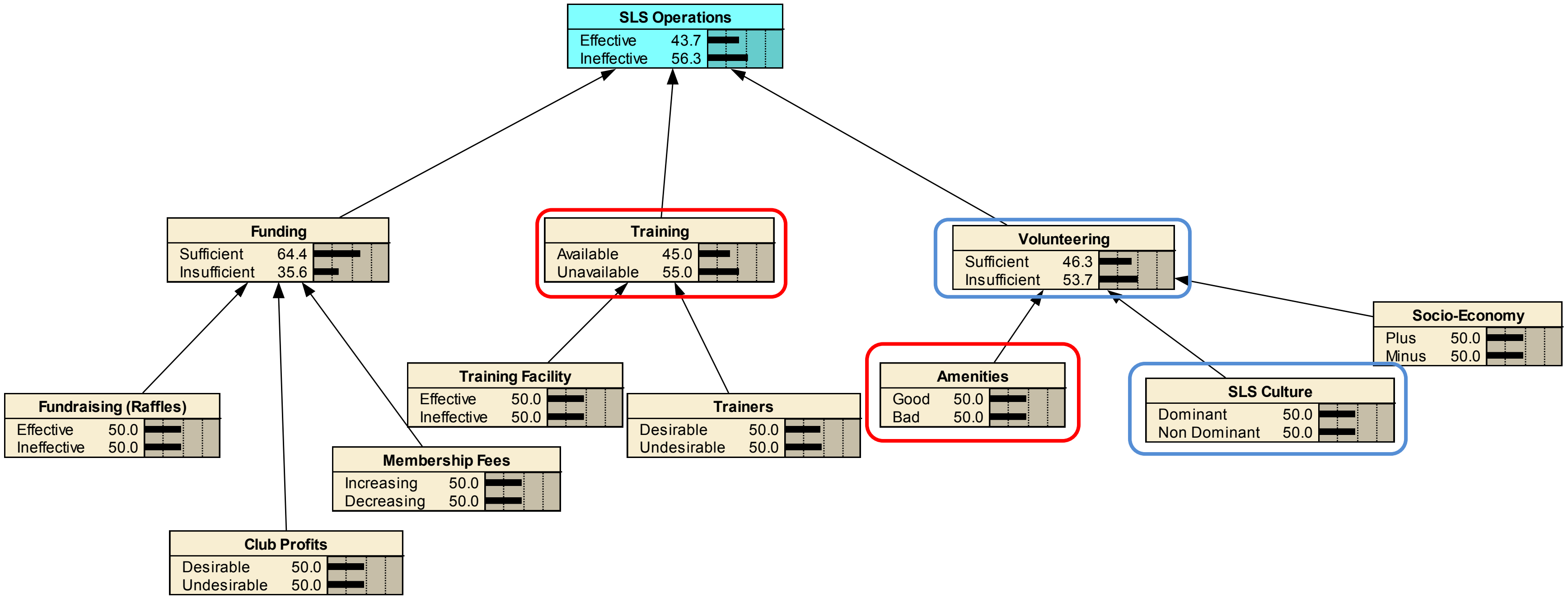

Figure A3:9: BBN developed around 'SLS Operations'

Variables highlighted by red rectangles highlight most influential path (on SLS operations), blue indicates second most influential path.
*note that there is no auxiliary node for stakeholders because there is only one set of CPTs.

Table A3.6: Sensitivity analysis (based upon 'SLS Operations'

NODE	MUTUAL INFO	PERCENT	VARIANCE OF BELIEFS
SLS_Operations	0.98841	100	0.2459956
Training	0.07446	7.53	0.0250522
Volunteering	0.06505	6.58	0.0219074
Funding	0.06206	6.28	0.0203873
Trainers	0.03160	3.2	0.0106915
Fundraising	0.01112	1.12	0.0037816
Membership_Fees	0.01112	1.12	0.0037816
SLS_Culture	0.00582	0.589	0.0019828
Training_Facility	0.00464	0.47	0.0015816
Socioeconomy	0.00404	0.409	0.0013770
Amenities	0.00259	0.262	0.0008813
Club_Profits	0.00172	0.174	0.0005869

Sensitivity analysis synopsis: The most influential variable acting on the priority issue is 'Training'. However, the sensitivity analysis (via the 'variance of beliefs' metric) indicates that the three 'primary level' variables are approximately equitable in their influence.

At the second hierarchical level:

- 'Trainers' is the most influential on 'Training'
- 'SLS Culture' is the most influential on ' olunteering'
- 'Fundraising' and 'Membership Fees' are equally influential upon 'Funding'.

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