2013

Coastal Adaptation Decision Pathways Project **(CAP)**

A Coastal Adaptation Pathways Project*

Conducted on behalf of the Sydney Coastal Councils Group by

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An initiative of the Department of Climate Change and Energy Efficiency

Climate Change Science Institute

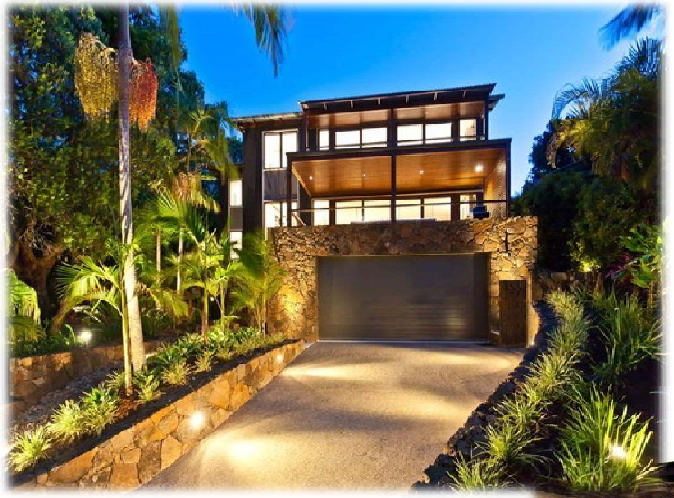
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

The evolution of adaptation

First Generation	Is climate change a problem?
Second Generation	What are the potential impacts of unmanaged climate change?
Third Generation	How do we effectively adapt to climate change?
Fourth Generation	Which adaptation options are the most effective?
Fifth Generation	Are we seeing the benefits?

Jones and Preston (2011)

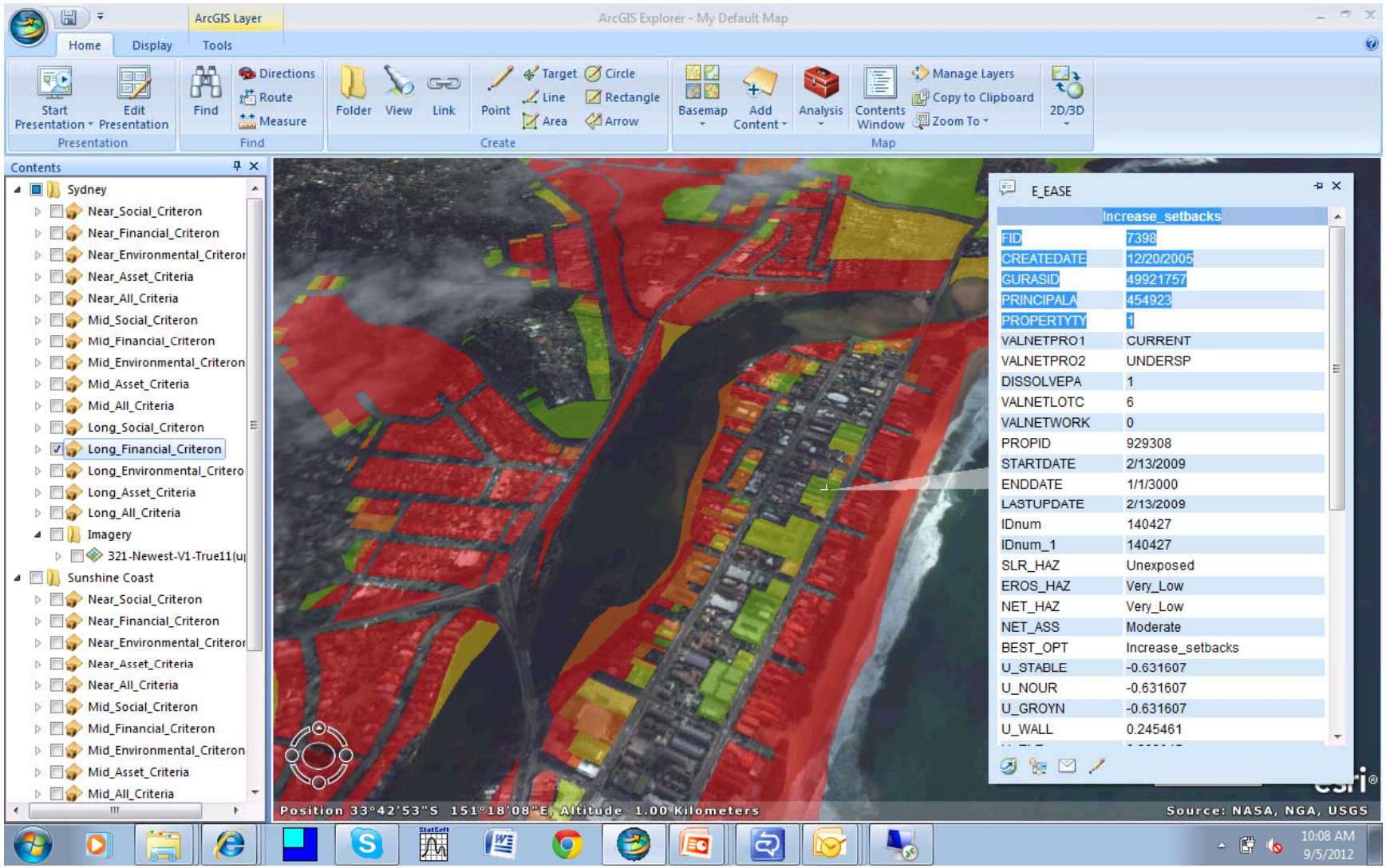
Coasts support a range of values



Prioritising coastal adaptation options

- Objectives
  - Explore multi-criteria analysis as a framework for guiding decision-making regarding coastal adaptation
  - Develop a set of MCA tools for three case study regions
  - Facilitate discussion among stakeholders regarding:
    - How do we evaluate and prioritise adaptation options?
    - Is there a role for MCA in that process?

Visualising coastal adaptation at the property scale



Our approach: Multi-criteria analysis (MCA)

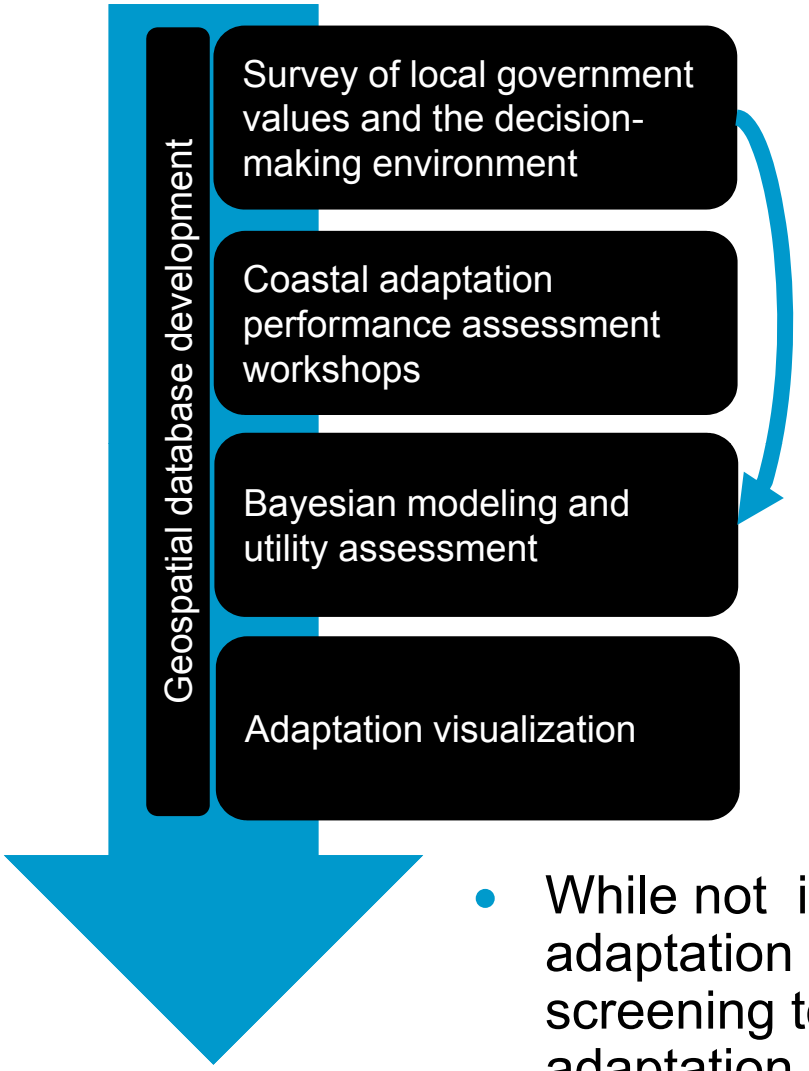
- MCA is an approach to policy analysis that incorporates monetary as well as non-monetary valuation methods for assessing costs and benefits of a particular action
- MCA requires a structured methodology for eliciting and integrating different values

Options	Criterion 1 *(Weight=High)*	Criterion 2 *(Weight=Low)*	Priority
Option 1	Yes	No	Medium
Option 2	Yes	Yes	High
Option 3	No	Yes	Low

- We sought to develop a flexible, participatory approach to MCA and the visualization of appropriate adaptation solutions

Case study locations

Our methodological process



- What is the relative importance of different values in organizational decision-making?
- How important are different coastal hazards over different time horizons?
- What factors drive changes in local government policies and measures?

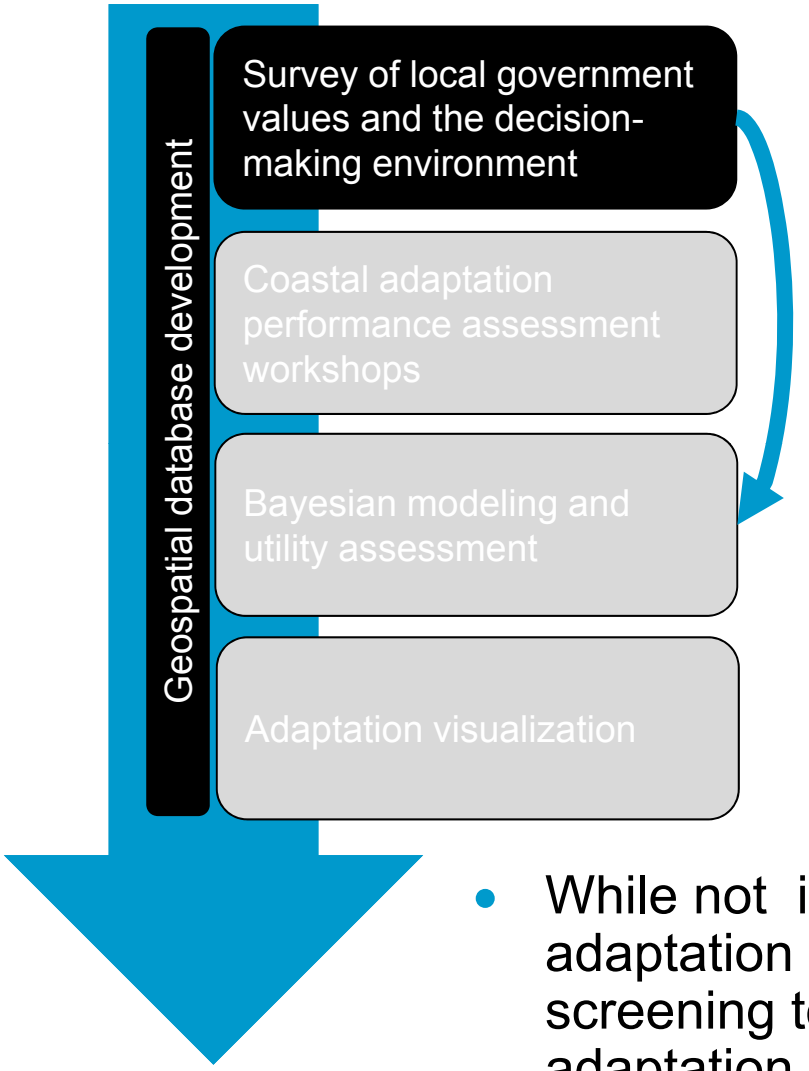
- Participatory performance assessment of different coastal adaptation options against different criteria/values (governance, financial, social, environmental) over different time horizons
- Based upon stakeholder's expertise and subjective judgment

- Development of Bayesian Belief Network (BBN) representing the conditional relationship among adaptation options and their performance
- Decision criteria weighted based upon data obtained from survey and geospatial information regarding risk to assets at the property scale
- Results in quantitative utility scores for each adaptation option
- Used to process property-specific "cases" for all at-risk properties in study regions

- Output from BBN exported to GIS environment for visualization
- Landscape imagery and HTML-enabled data layers allow for easy access to property-scale information

- While not intended to replace detailed site-specific adaptation studies, this methodology provides a screening tool and a proof-of-concept for a spatial adaptation information system

Our methodological process



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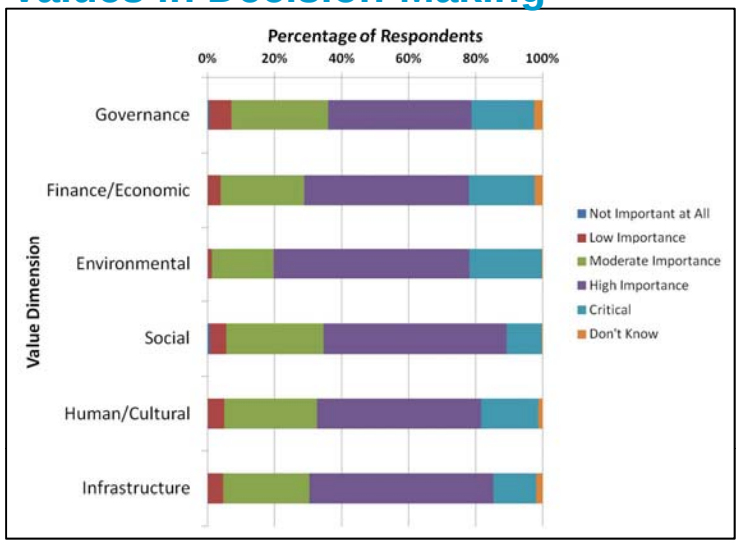
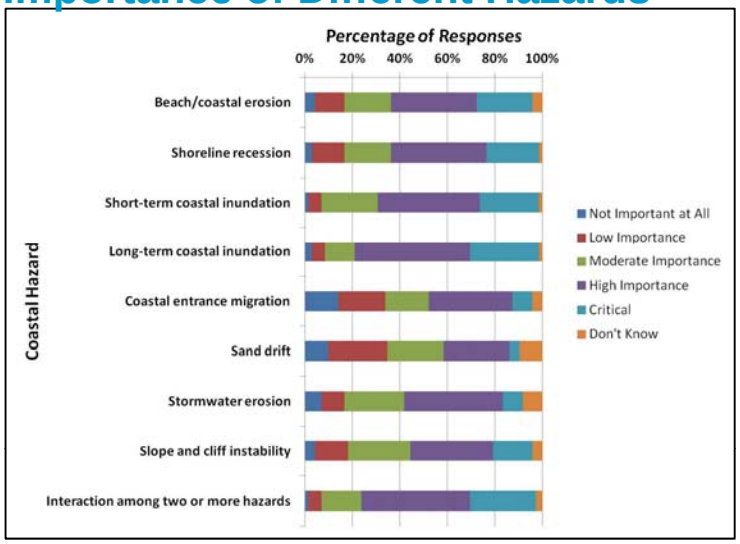
The survey elucidated the decision context

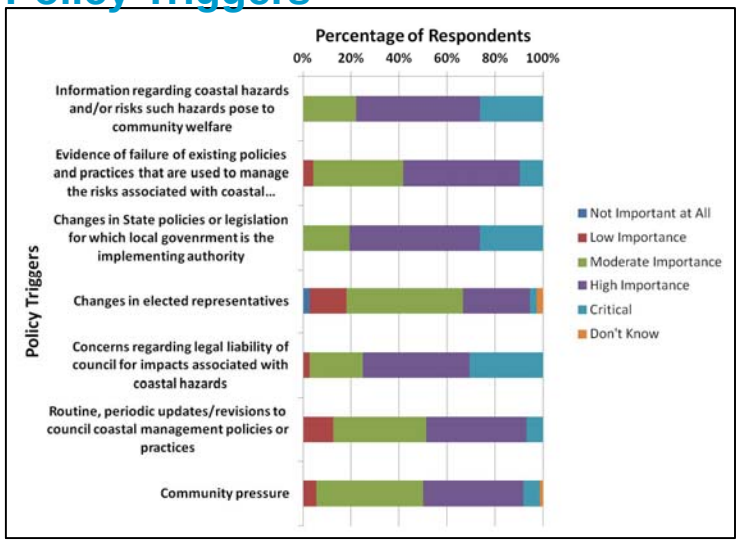
Values in Decision-Making



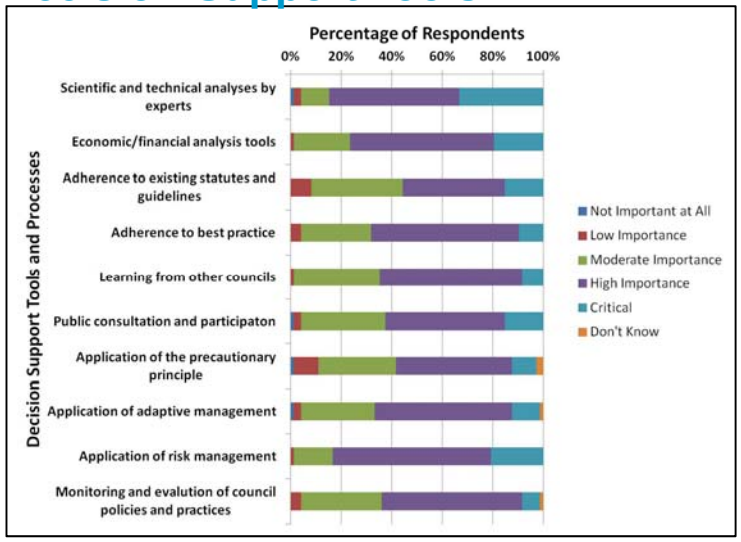
Importance of Different Hazards



Policy Triggers



Decision-Support Tools



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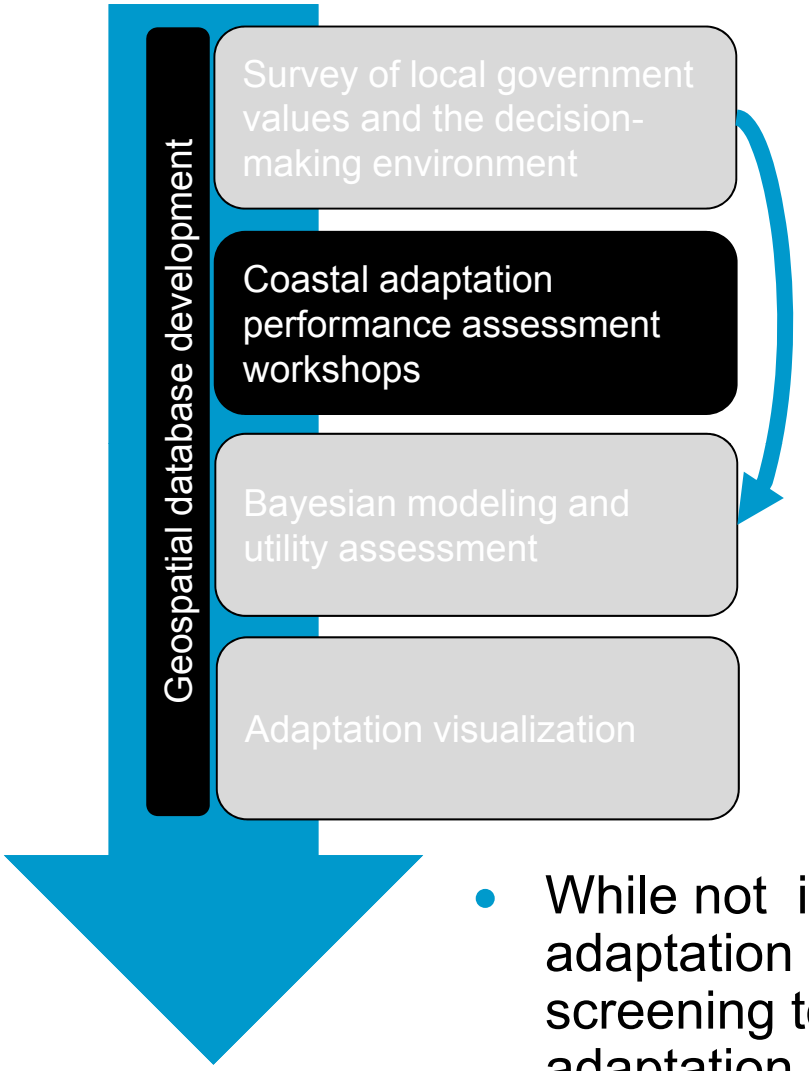

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Performance assessment workshops

- Staff from local government were divided into four groups, each focused on one of the key values dimensions around which MCA criteria were organised:
  - Governance
  - Financial values
  - Social values
  - Environmental values
- Staff then worked to assess the performance of 15 different adaptation options against 16 criteria (4 per dimension) and three different time horizons:
  - Near (0-10 years), Medium (10-25 years), Long (>25 years)

Coastal adaptation options

- Local government staff evaluated a range of adaptation options that included:
  - Options frequently identified in the international literature
  - Options frequently identified within adaptation plans of Australian local governments

Protection	**Retreat**
1) Shoreline stabilization 2) Beach nourishment	9) Acquisition of at-risk properties 10) Increase setbacks on at-risk properties
3) Groynes or artificial headlands	11) Block development on at-risk properties
4) Sea walls or revetments	12) Implement rolling easements
Accommodation	**Cross-Cutting Options**
5) Elevation of structures	13) Community education about risk
6) Removable structures in at-risk areas	14) Assessments of vulnerability and risk
7) Risk spreading mechanisms	15) Integrated coastal zone management
8) Water proofing of at-risk properties	

Criteria used for performance assessment

Governance	
Criterion G1	This adaptation option is consistent with, and could be readily implemented under, existing local and state planning policy
Criterion G2	This adaptation option could be independently implemented by council without involving other levels of government or external organizations
Criterion G3	This adaptation option is an effective strategy for limiting council liability for losses associated with coastal hazards and sea-level rise
Criterion G4	Implementing this adaptation option would not infringe upon existing rights of property owners
Financial	
Criterion F1	This adaptation option is effective at protecting coastal properties and/or critical infrastructure from financial damage caused by coastal hazards
Criterion F2	Implementing this adaptation option would not impose a significant financial burden on council
Criterion F3	Implementing this adaptation option would not impose a significant financial burden on individual property owners or businesses affected by the adaptation option
Criterion F4	Implementation of this adaptation strategy would keep the door open for the pursuit of alternative adaptation options in the future (i.e., preservation of 'real options')
Social	
Criterion S1	This adaptation option is effective at protecting socially or culturally significant locations from damage caused by coastal hazards
Criterion S2	This adaptation option is effective at protecting public health and safety from coastal hazards
Criterion S3	This adaptation option could be implemented without reinforcing or enhancing social inequities within the community (e.g., unequal distribution of costs and/or benefits)
Criterion S4	Implementation of this adaptation option would be readily accepted by the community and/or individual property owners
Environmental	
Criterion E1	This adaptation option is effective at enabling ecological assets (e.g., native vegetation and wetlands) to cope naturally with coastal erosion and inundation
Criterion E2	Implementing this adaptation option would enhance the natural amenity and/or ecological value of a given location or community
Criterion E3	Implementing this adaptation option at one location would not contribute to adverse ecological outcomes at other locations
Criterion E4	Implementing this adaptation option would provide existing and/or future development with a natural buffer from coastal processes and hazards

Example workshop assessment template

Governance Dimensions

Criterion G1: This adaptation option is consistent with, and could be readily implemented under, existing local and state planning policy

Adaptation Options	Time Horizon		
	Near-Term (Up to 10 Years)	Mid-Term (10 to 25 Years)	Long-Term (>25 Years)
Protect			
1) Shoreline stabilization	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
2) Beach nourishment	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
3) Groynes or artificial headlines	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
4) Sea walls or revetments	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
Accommodate			
5) Elevation of structures	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
6) Removable structures in at-risk areas	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
7) Risk spreading mechanisms	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
8) Water proofing of at-risk properties	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
Retreat			
9) Acquisition of at-risk properties	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
10) Increase setbacks on at-risk properties	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
11) Block development on at-risk properties	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
12) Implement rolling easements	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
Cross-Cutting Strategies			
13) Community education about risk	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
14) Assessments of vulnerability and risk	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
15) Integrated coastal zone management	SA A NAND D SD	SA A NAND D SD	SA A NAND D SD
SA=Strongly Agree A=Agree NAND=Neither Agree nor Disagree A=Agree SA=Strongly Agree			

Please circle the response in each cell of the table to indicate the extent to which each adaptation option is consistent with the criterion as stated

Results from the workshops were organised into performance matrices

- Each cell of the matrix represents the performance score for a given adaptation option and criterion
  - Scores range from -2 (poor performance) to +2 (high performance)

Performance Matrix – Short Time Horizon (0-10 years)/All regions

Adaptation Option	G1	G2	G3	G4	F1	F2	F3	F4	S1	S2	S3	S4	E1	E2	E3	E4
Shoreline stabilization	1.6	-0.1	0.9	0.5	0.9	0.7	0.6	1.4	1.6	1.1	0.9	1.3	1.3	1.4	1.2	1.2
Beach nourishment	1.5	-0.7	1.1	1.0	0.6	-0.7	-0.5	-0.1	1.0	0.8	0.7	1.0	0.6	0.3	-0.5	0.2
Groynes or artificial headlands	1.3	-1.5	0.8	0.5	0.5	-1.0	-0.3	-0.5	1.0	0.4	0.5	0.5	-0.1	-0.8	-1.2	-0.6
Sea walls or revetments	1.4	-1.0	0.9	-0.1	1.3	-1.1	-0.5	-1.0	0.7	0.8	0.1	0.4	-0.4	-1.1	-0.8	-0.6
Elevation of structures	1.1	0.7	0.9	-0.4	0.9	-0.9	-0.6	0.0	0.4	0.3	0.0	0.2	0.2	-0.3	0.6	0.3
Removable structures in at-risk areas	1.0	0.6	1.0	-0.3	0.5	0.6	0.1	1.0	0.9	0.3	0.8	0.7	0.2	0.4	0.1	0.4
Risk spreading mechanisms	-0.2	-0.5	0.5	0.2	0.7	-0.4	-0.5	0.3	0.0	-0.3	0.4	0.1	-0.8	-1.0	-0.1	-0.6
Water proofing of at-risk properties	1.1	0.9	0.7	0.7	0.5	-0.5	-0.5	0.2	-0.1	0.1	-0.2	-0.1	-0.6	-0.4	0.1	-0.2
Acquisition of at-risk properties	0.6	0.7	-0.3	-0.5	0.5	-1.8	0.0	-0.5	-0.1	0.8	-0.5	-0.1	0.6	0.3	0.5	0.7
Increase setbacks on at-risk properties	0.4	-0.3	0.7	-0.6	1.1	1.0	-0.5	1.2	0.4	1.2	0.7	0.6	1.5	1.0	0.5	1.0
Block development on at-risk properties	1.0	-0.1	0.7	-0.9	0.0	0.8	-1.4	1.2	-0.3	1.1	0.9	0.4	1.0	1.0	1.0	1.0
Implement rolling easements	-0.5	-0.8	0.3	-1.0	0.1	0.9	-0.7	0.9	-0.1	1.1	0.8	0.5	0.7	-0.1	0.5	0.3
Community education about risk	1.5	1.5	1.1	1.2	0.4	0.5	0.8	1.5	0.9	1.3	1.1	1.1	0.8	1.0	1.1	1.0
Assessments of vulnerability and risk	1.5	1.2	0.8	0.8	0.9	-0.3	0.7	1.3	0.5	0.7	1.2	0.9	1.2	1.2	1.2	1.2
Integrated coastal zone management	1.1	-0.6	0.6	0.1	0.9	-0.3	0.9	1.4	1.1	0.9	1.2	1.1	1.5	1.4	1.5	1.4

Results from the workshops were organised into performance matrices

- Each cell of the matrix represents the performance score for a given adaptation option and criterion
  - Scores range from -2 (poor performance) to +2 (high performance)

Performance Matrix – Long Time Horizon (25+ years)/All regions

Adaptation Option	G1	G2	G3	G4	F1	F2	F3	F4	S1	S2	S3	S4	E1	E2	E3	E4
Shoreline stabilization	0.8	-0.3	0.5	0.5	-0.6	-0.1	0.7	1.2	0.2	0.3	0.5	0.5	0.2	1.0	0.5	0.5
Beach nourishment	0.8	-0.9	0.5	0.9	-0.6	-1.5	-0.6	-0.3	0.4	0.1	0.6	0.5	-1.1	-0.3	-0.9	-0.7
Groynes or artificial headlands	0.5	-1.4	0.1	0.5	-0.5	-0.8	-0.2	0.3	0.2	-0.2	0.2	0.0	-0.9	-0.9	-1.4	-1.0
Sea walls or revetments	0.6	-0.7	0.3	-0.1	0.3	-0.9	-0.3	-0.5	0.3	0.3	-0.1	0.1	-0.5	-1.3	-1.2	-0.8
Elevation of structures	0.5	0.6	0.3	-0.5	0.3	-0.4	-0.5	-0.2	0.2	-0.1	-0.1	0.0	-0.5	-0.5	0.2	-0.3
Removable structures in at-risk areas	0.5	0.6	0.7	-0.5	0.5	0.9	0.6	1.1	0.7	0.2	0.5	0.5	0.0	0.5	-0.2	0.1
Risk spreading mechanisms	0.3	-0.3	0.5	0.2	-0.2	-0.5	-0.8	-0.4	-0.1	-0.5	0.4	0.1	-0.8	-1.2	-0.5	-0.8
Water proofing of at-risk properties	0.5	0.7	0.6	0.5	-0.8	-0.8	-0.1	-0.4	-1.0	-0.6	-0.4	-0.7	-1.2	-0.5	-0.4	-0.7
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Block development on at-risk properties	0.9	0.3	0.5	-0.7	1.0	0.9	-0.2	0.9	-0.9	1.2	0.9	0.4	1.3	1.6	0.8	1.3
Implement rolling easements	0.0	-0.5	0.2	-0.7	-0.6	0.9	-0.3	0.8	-0.4	0.8	0.9	0.3	0.8	0.6	0.2	0.5
Community education about risk	1.3	1.2	0.9	1.1	1.0	0.9	1.0	1.4	0.8	1.2	1.0	1.1	0.8	0.9	1.2	1.0
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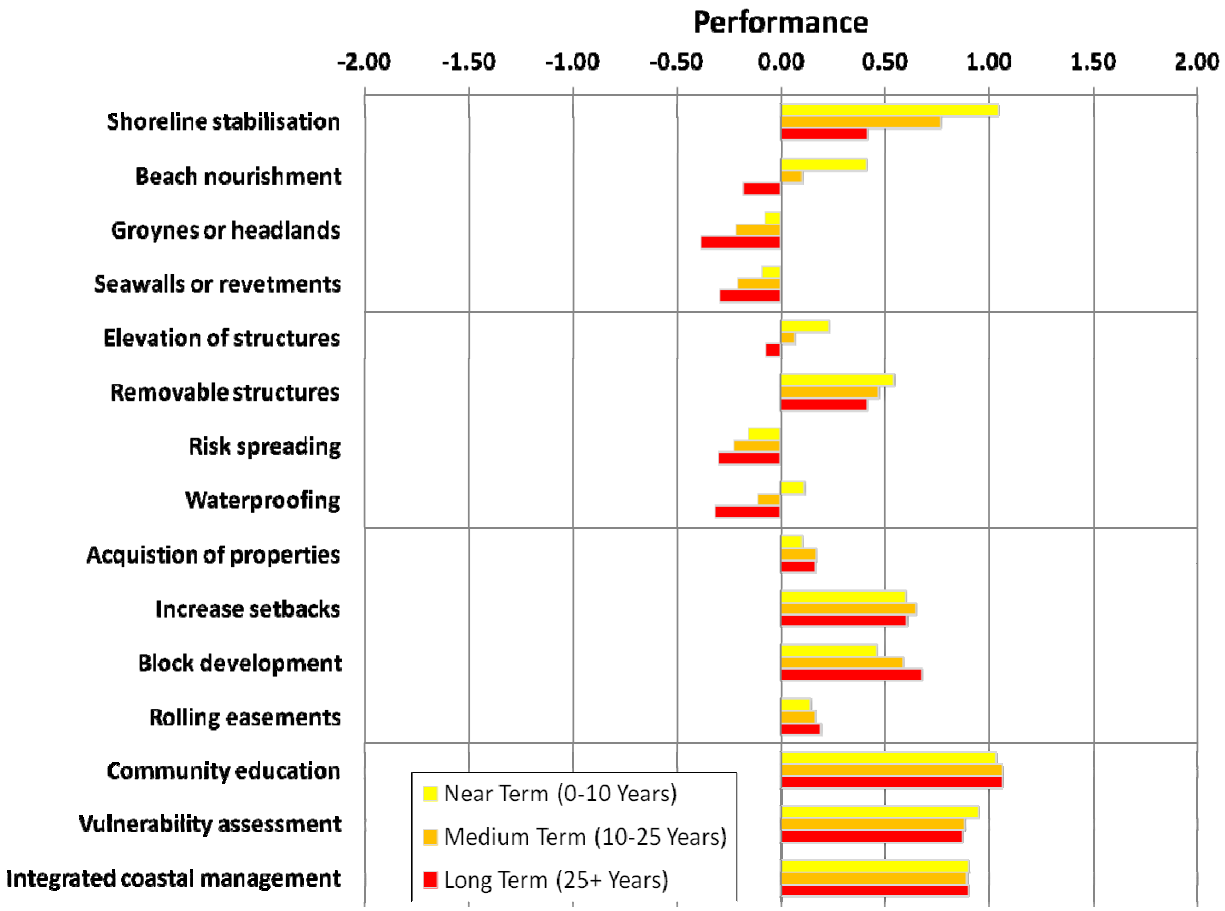
Scores for individual criteria could be aggregated to yield net performance

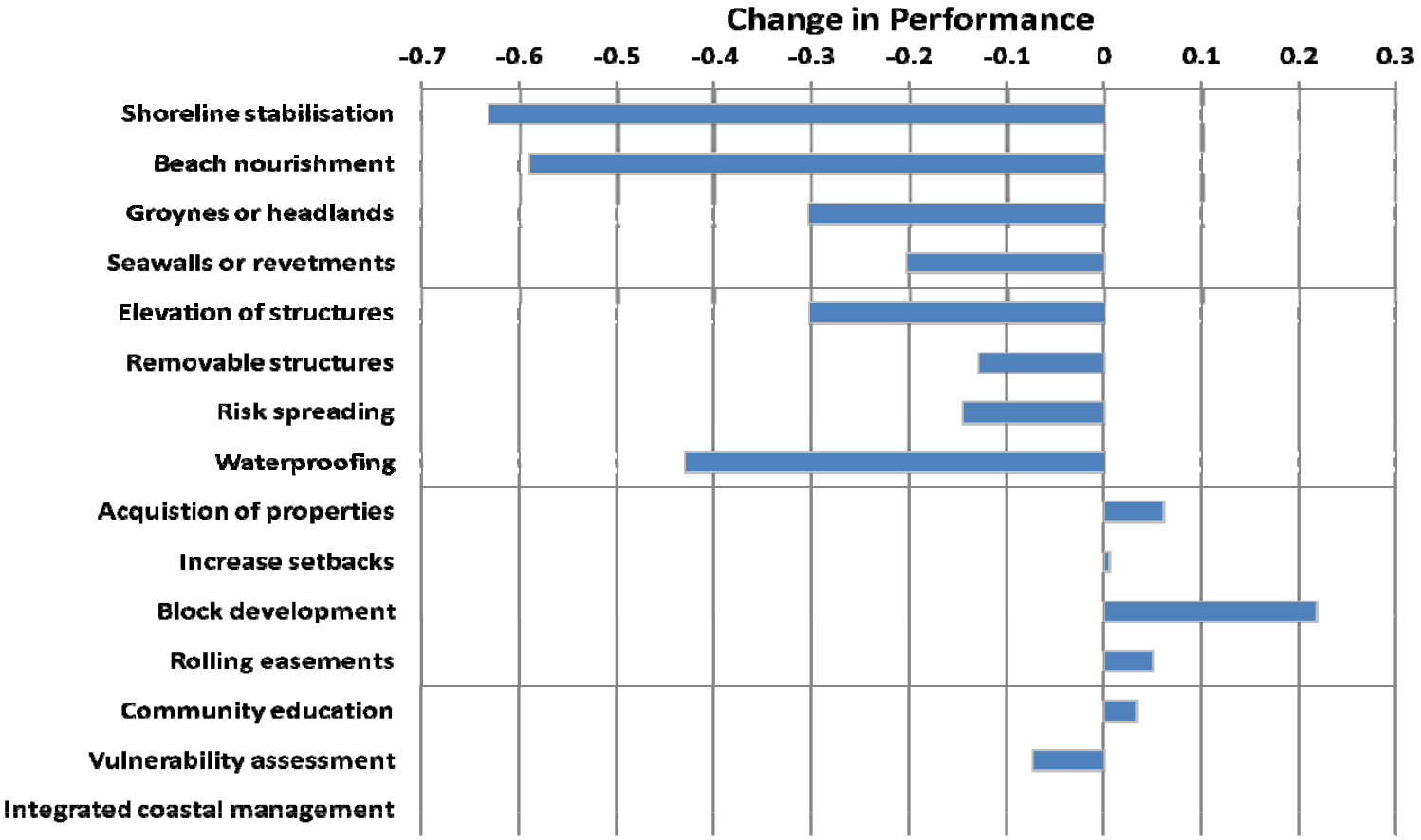


- The performance of most options declines with a longer time horizon
- Some options that appear useful over the near-term are counter-productive over the long-term
- Others appear to be robust over different time scales

Crosscutting/capacity-building options are consistent high performers

Protection measures experience the greatest decline in performance with time

- Comparing near-term and long-term performance indicates which options are associated with strong time preferences

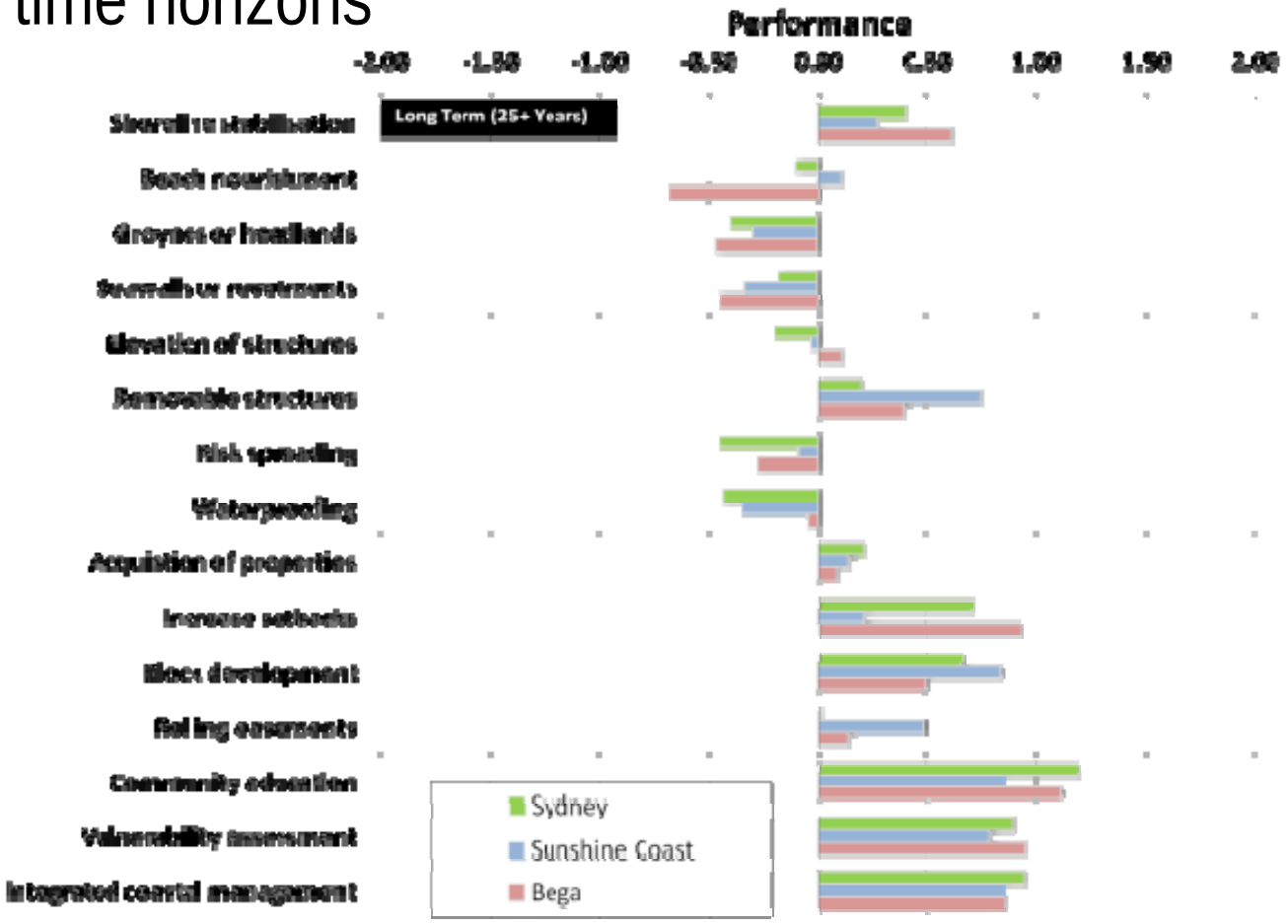


Perceptions of the utility of different options varied across case study regions

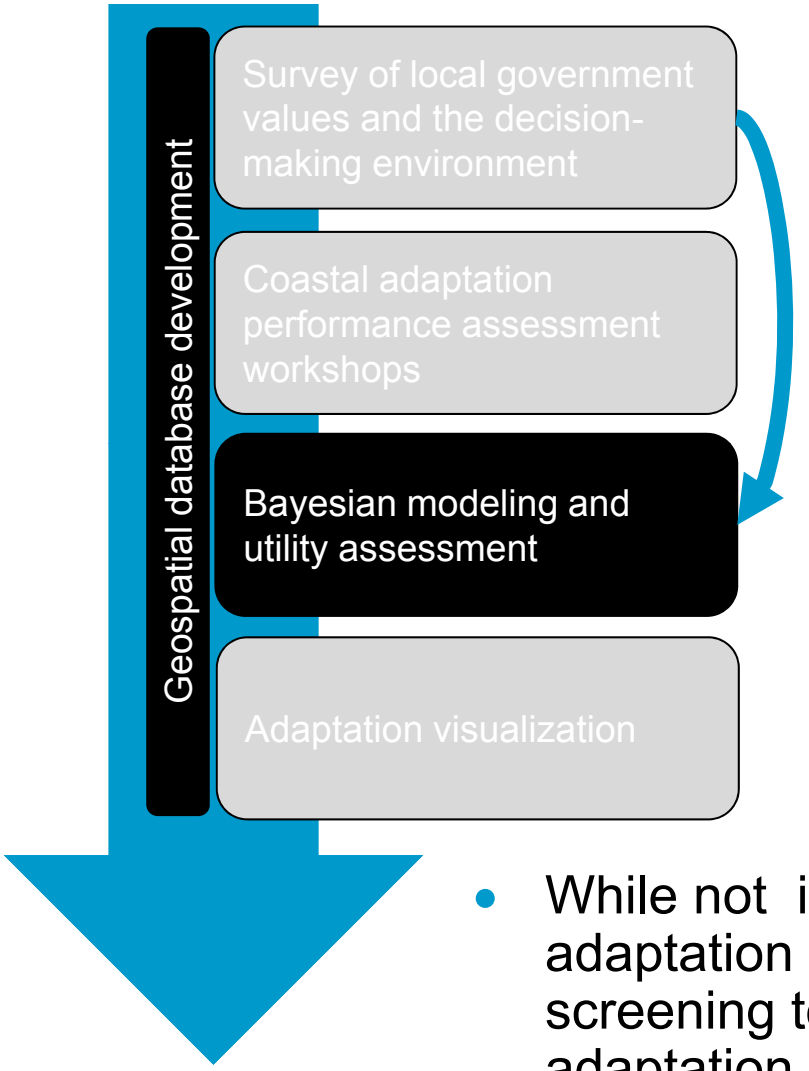
- Preferences likely a function of past experience with different management options

Perceptions of the utility of different options varied across case study regions

- However, preferences among study regions converge with longer time horizons



Our methodological process



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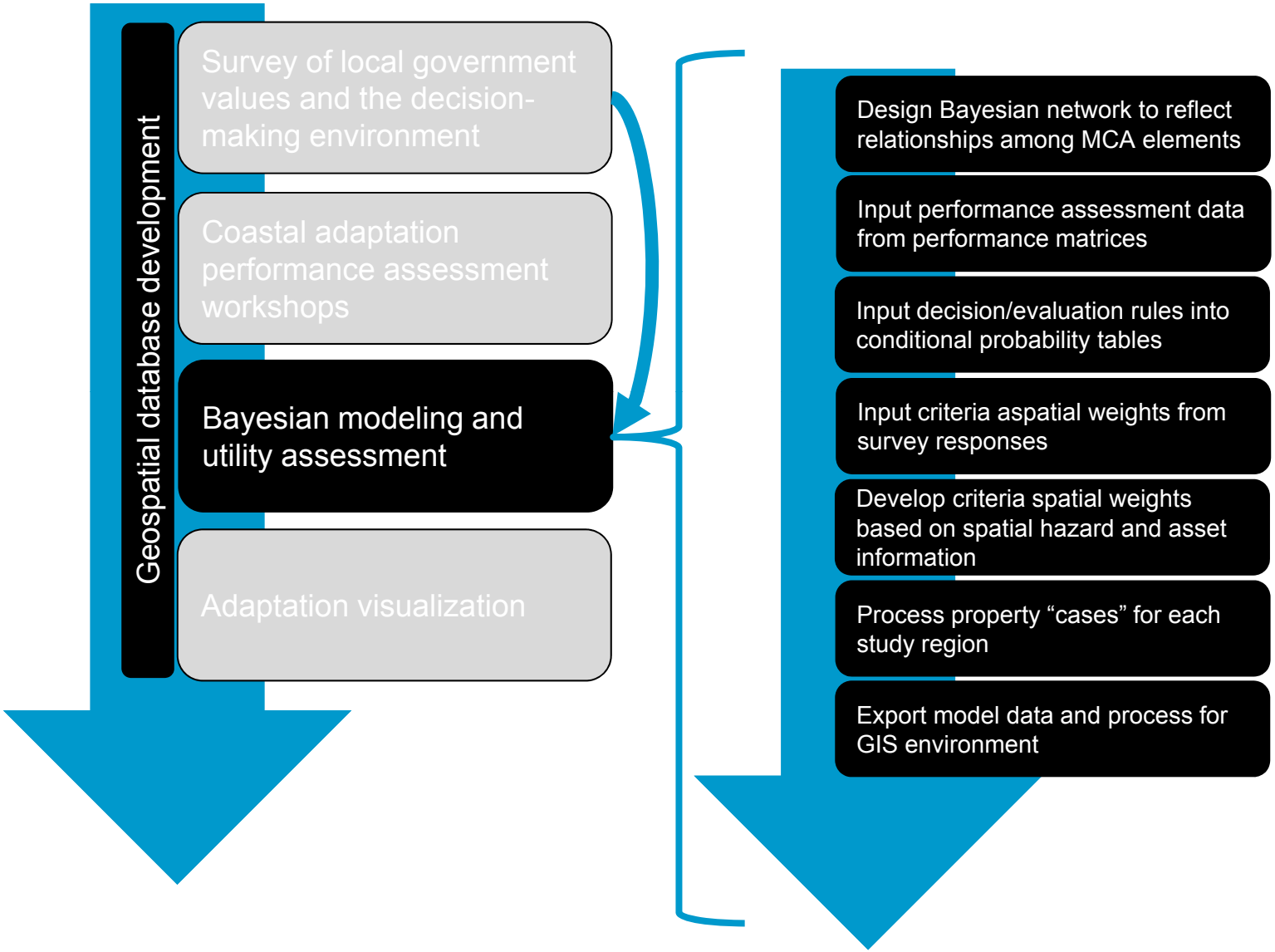
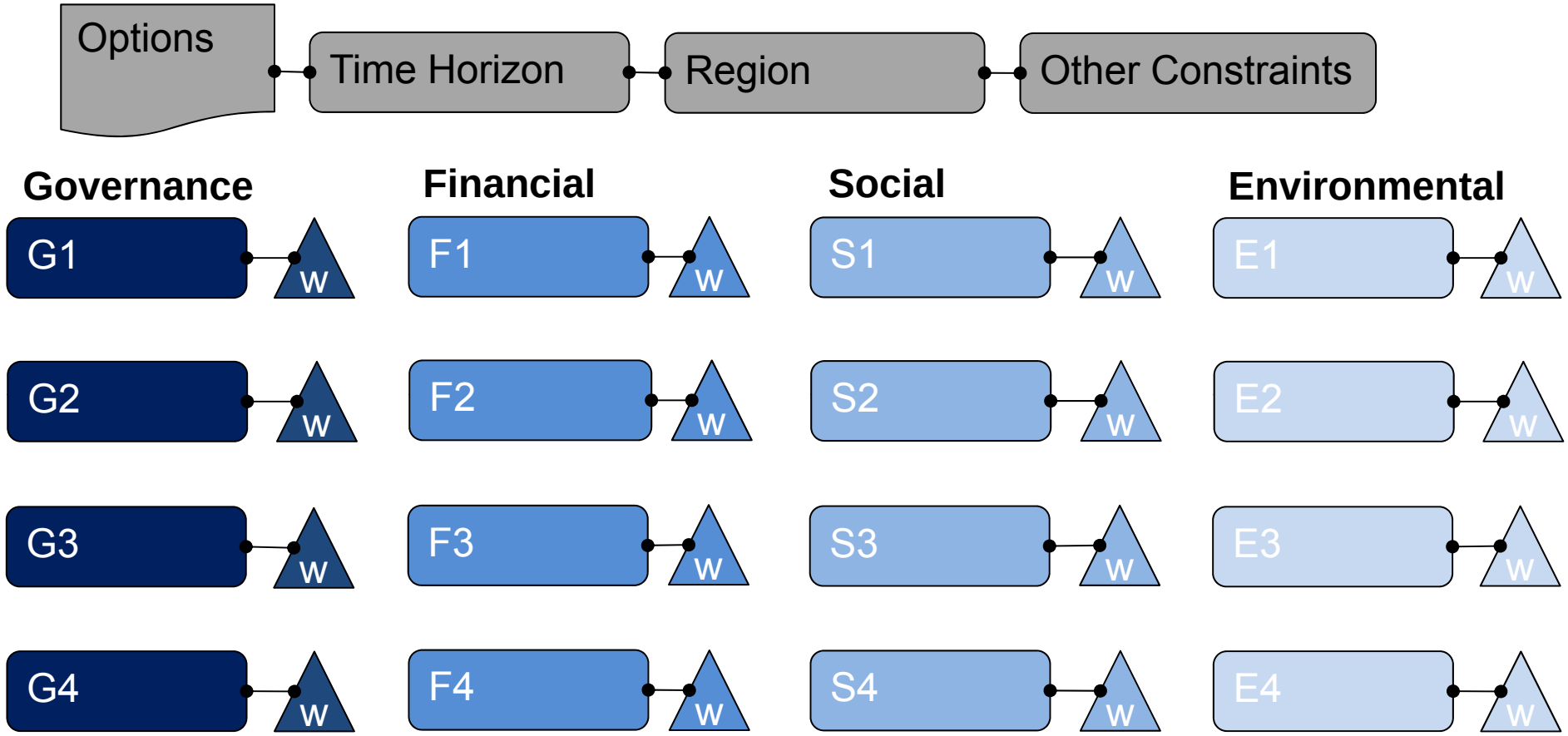
Applying and visualising MCA methods at the property scale

- The performance matrices enable one to ‘benchmark’ general attitudes among local government staff regarding appropriate adaptation options
- Yet, to be useful in decision-support, such information must be spatially disaggregated to the scale at which decisions regarding local planning and development are made
- Our approach integrated the stakeholder perspectives from the performance matrices with risk-weighted criteria and a set of decision rules

Our methodological process: Bayesian model



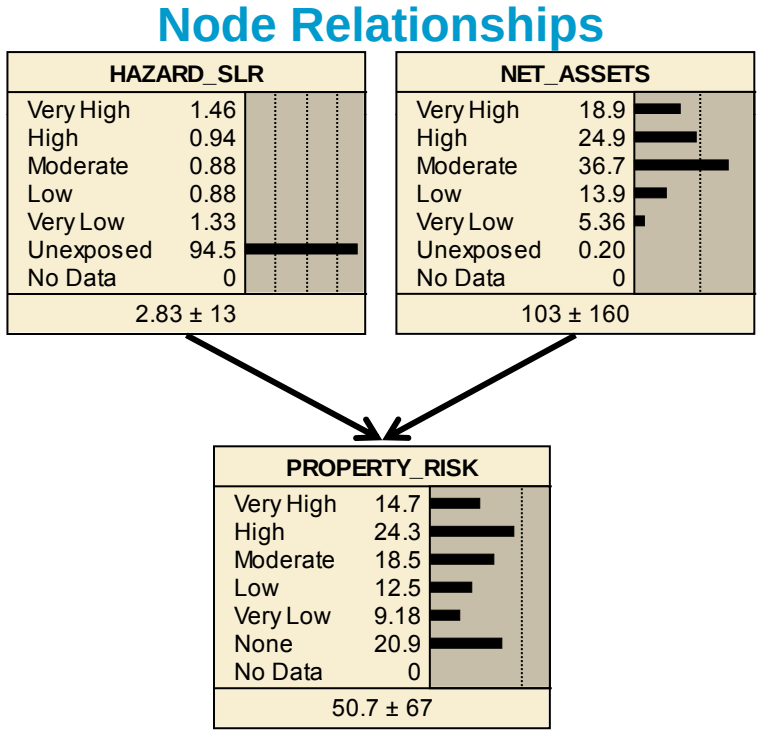
Overview of coastal MCA methods



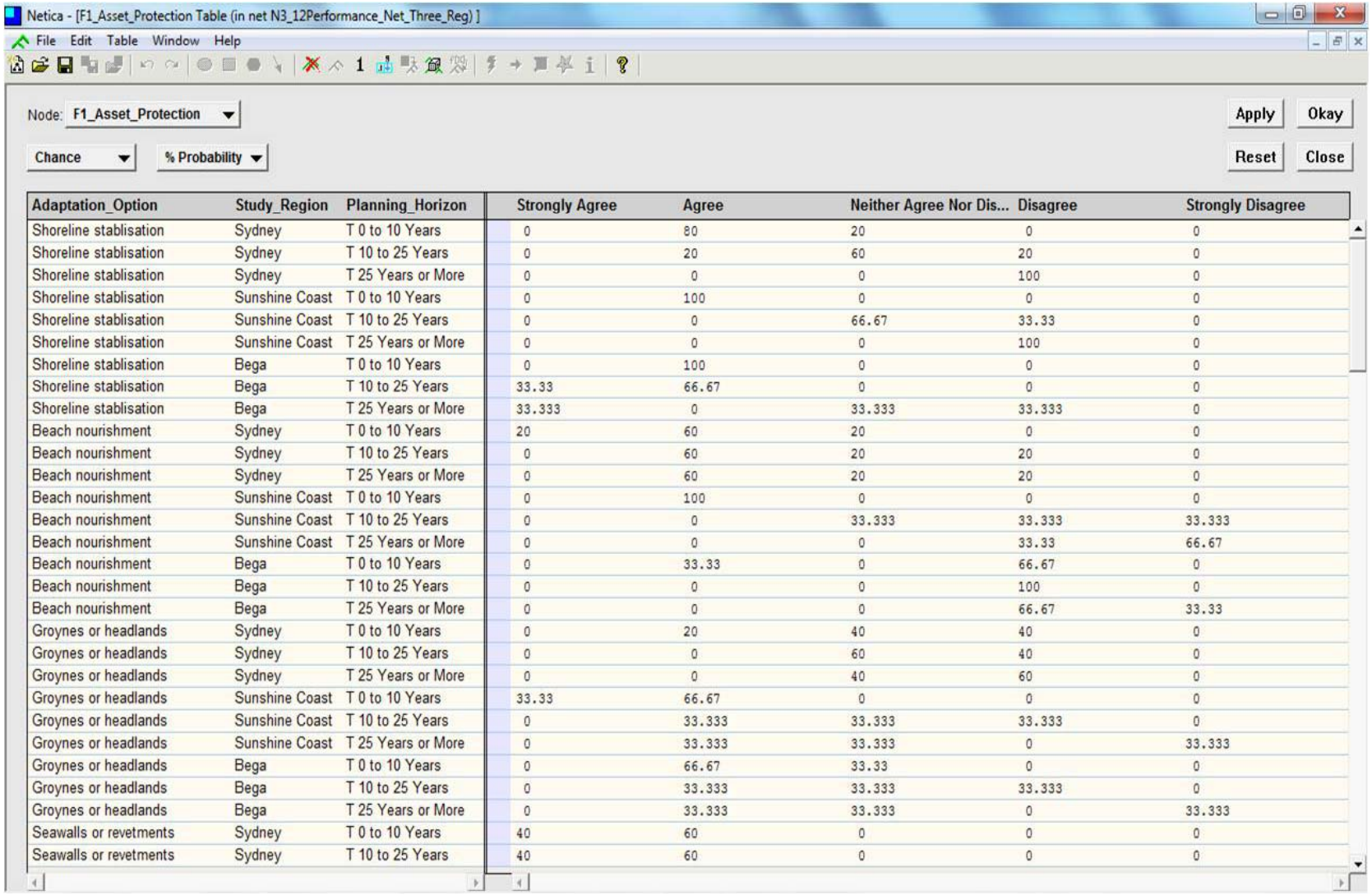
- Performance of different options were based on prior workshops
- Weights were derived from the survey of local government values or location specific risk assessment (hazards x assets)

Bayesian belief networks

- Bayesian networks are probabilistic graphical representations of the conditional relationship among different variables in a system
- Each variable in the network is represented as an independent (parent) or dependent (child) node
- Relationships among parents and children can be defined by equations or conditional probability tables
- Strengths
  - Flexible
  - Readily incorporate uncertainty information
  - Easy to link to a GIS environment
  - Seen extensive use in Australia



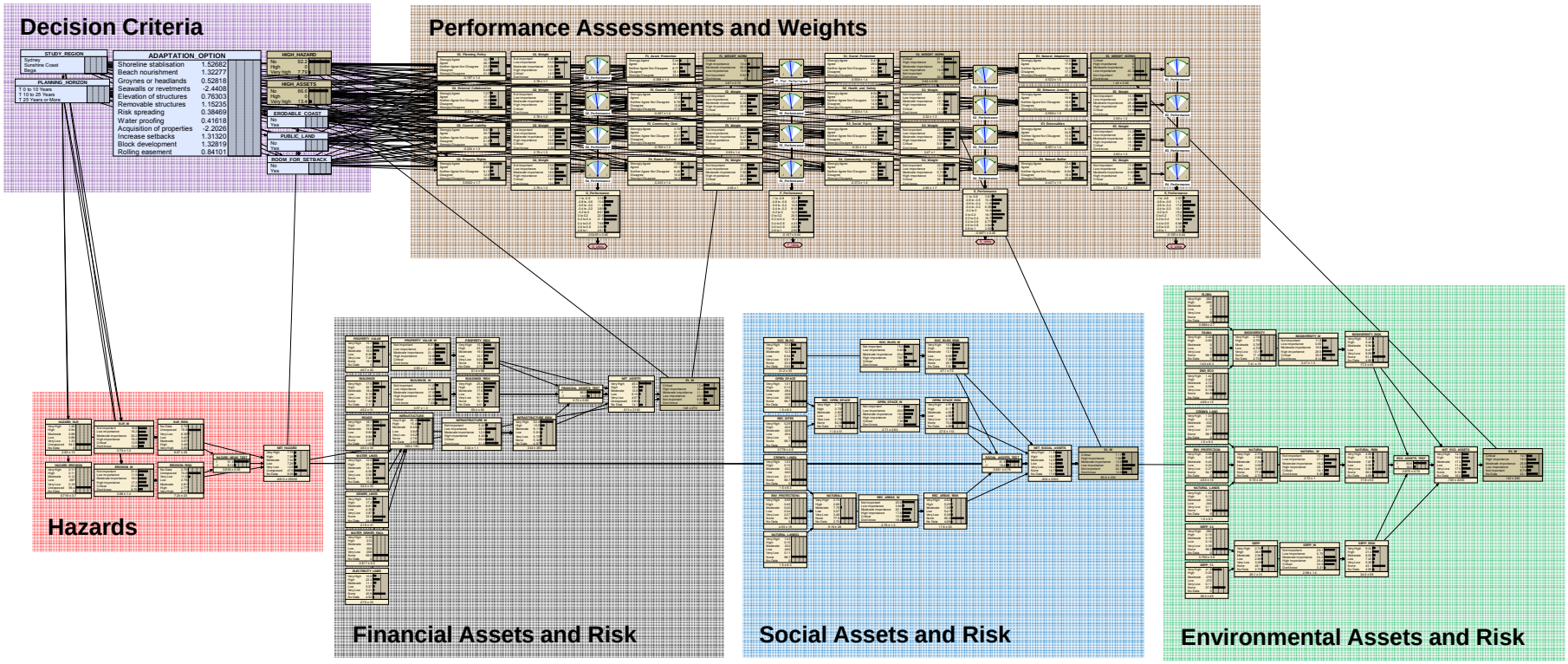
Example: Conditional probability table (CPT)



Adaptation_Option	Study_Region	Planning_Horizon	Strongly Agree	Agree	Neither Agree Nor Dis...	Disagree	Strongly Disagree
Shoreline stablisation	Sydney	T 0 to 10 Years	0	80	20	0	0
Shoreline stablisation	Sydney	T 10 to 25 Years	0	20	60	20	0
Shoreline stablisation	Sydney	T 25 Years or More	0	0	0	100	0
Shoreline stablisation	Sunshine Coast	T 0 to 10 Years	0	100	0	0	0
Shoreline stablisation	Sunshine Coast	T 10 to 25 Years	0	0	66.67	33.33	0
Shoreline stablisation	Sunshine Coast	T 25 Years or More	0	0	0	100	0
Shoreline stablisation	Bega	T 0 to 10 Years	0	100	0	0	0
Shoreline stablisation	Bega	T 10 to 25 Years	33.33	66.67	0	0	0
Shoreline stablisation	Bega	T 25 Years or More	33.333	0	33.333	33.333	0
Beach nourishment	Sydney	T 0 to 10 Years	20	60	20	0	0
Beach nourishment	Sydney	T 10 to 25 Years	0	60	20	20	0
Beach nourishment	Sydney	T 25 Years or More	0	60	20	20	0
Beach nourishment	Sunshine Coast	T 0 to 10 Years	0	100	0	0	0
Beach nourishment	Sunshine Coast	T 10 to 25 Years	0	0	33.333	33.333	33.333
Beach nourishment	Sunshine Coast	T 25 Years or More	0	0	0	33.33	66.67
Beach nourishment	Bega	T 0 to 10 Years	0	33.33	0	66.67	0
Beach nourishment	Bega	T 10 to 25 Years	0	0	0	100	0
Beach nourishment	Bega	T 25 Years or More	0	0	0	66.67	33.33
Groynes or headlands	Sydney	T 0 to 10 Years	0	20	40	40	0
Groynes or headlands	Sydney	T 10 to 25 Years	0	0	60	40	0
Groynes or headlands	Sydney	T 25 Years or More	0	0	40	60	0
Groynes or headlands	Sunshine Coast	T 0 to 10 Years	33.33	66.67	0	0	0
Groynes or headlands	Sunshine Coast	T 10 to 25 Years	0	33.333	33.333	33.333	0
Groynes or headlands	Sunshine Coast	T 25 Years or More	0	33.333	33.333	0	33.333
Groynes or headlands	Bega	T 0 to 10 Years	0	66.67	33.33	0	0
Groynes or headlands	Bega	T 10 to 25 Years	0	33.333	33.333	33.333	0
Groynes or headlands	Bega	T 25 Years or More	0	33.333	33.333	0	33.333
Seawalls or revetments	Sydney	T 0 to 10 Years	40	60	0	0	0
Seawalls or revetments	Sydney	T 10 to 25 Years	40	60	0	0	0

Bayesian MCA model with spatial elements

- BBN represents relationships among different variables
  - Prior distributions for each variable derived from workshops (performance assessment), survey results (weights), or geospatial data (hazards and assets)



Multiple methods were used to reflect relationships among nodes

- **Performance nodes** – contain stakeholder perceptions of the performance of different options against aforementioned criteria
- **Weight nodes** – weight performance nodes based upon survey data or the risk posed by coastal hazards to assets
- **Risk nodes** – estimate risk to assets based upon hazard and asset distributions
  - **Hazard nodes** – reflect likelihood of exposure to erosion and/or storm surge over different time horizons
  - **Asset nodes** – represent the relative complement of financial, social, or environmental assets
- **Decision nodes** – reflect different decision criteria that influence performance nodes
- **Utility nodes** – aggregate weighted performance of options under different conditions to calculate net utility

Representing coastal hazards

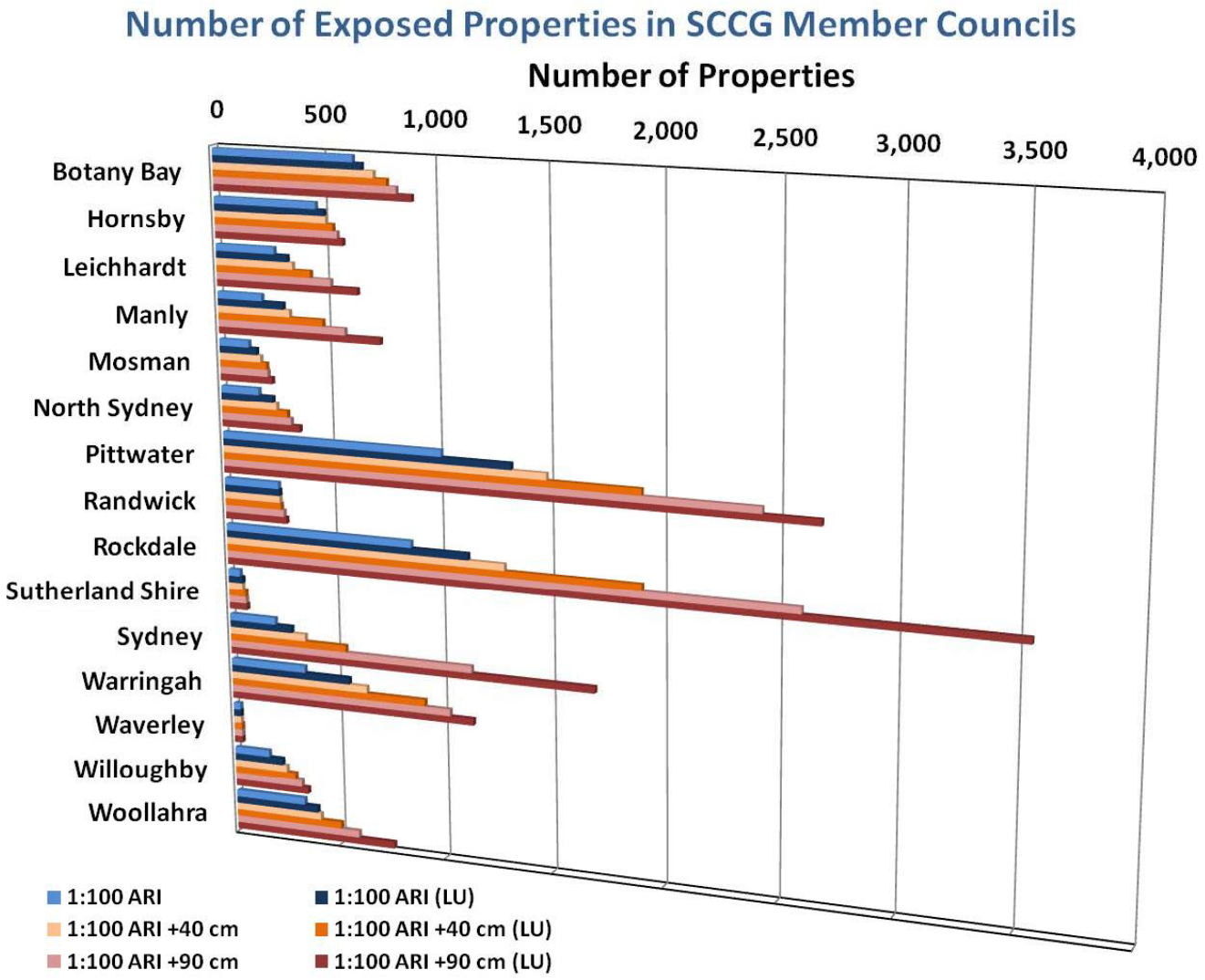
- Inundation hazard
  - Derived from SCCG project "Mapping and Responding to Coastal Inundation"
  - 1:100 year layers
    - +0 cm SLR ("near-term")
    - +40 cm SLR ("medium-term")
    - +90 cm SLR ("long-term")
  - Alternative data sources were used in other case study regions
- Erosion hazard
  - Based on NSW Coastal Risk Management Guide (NSW, 2010)
  - Used SMARTLINE to identify coasts susceptible to erosion
  - Applied Brunn rule to estimate erosion in buffer areas landward of coastline
    - Still water level for different SLR scenarios was modelled from NSW guidance
    - Multiplied SWL by 50

MCA model was used to process all properties/cases in each study region

Cast Study Region	Number of Parcels/Properties	Number of Exposed Parcels/Properties
Bega Valley Shire Council	~24,863	~1,730 (7%)
Sunshine Coast Council	~201,420	~48,022 (24%)
Sydney Coastal Councils Group (15 member councils)	~362,151	~21,162 (6%)

- Bayesian model and variable priors were paramaterised for each case study region based upon all properties
- Model was then used to process only those cases for which there was potential for future exposure

Properties exposed to inundation

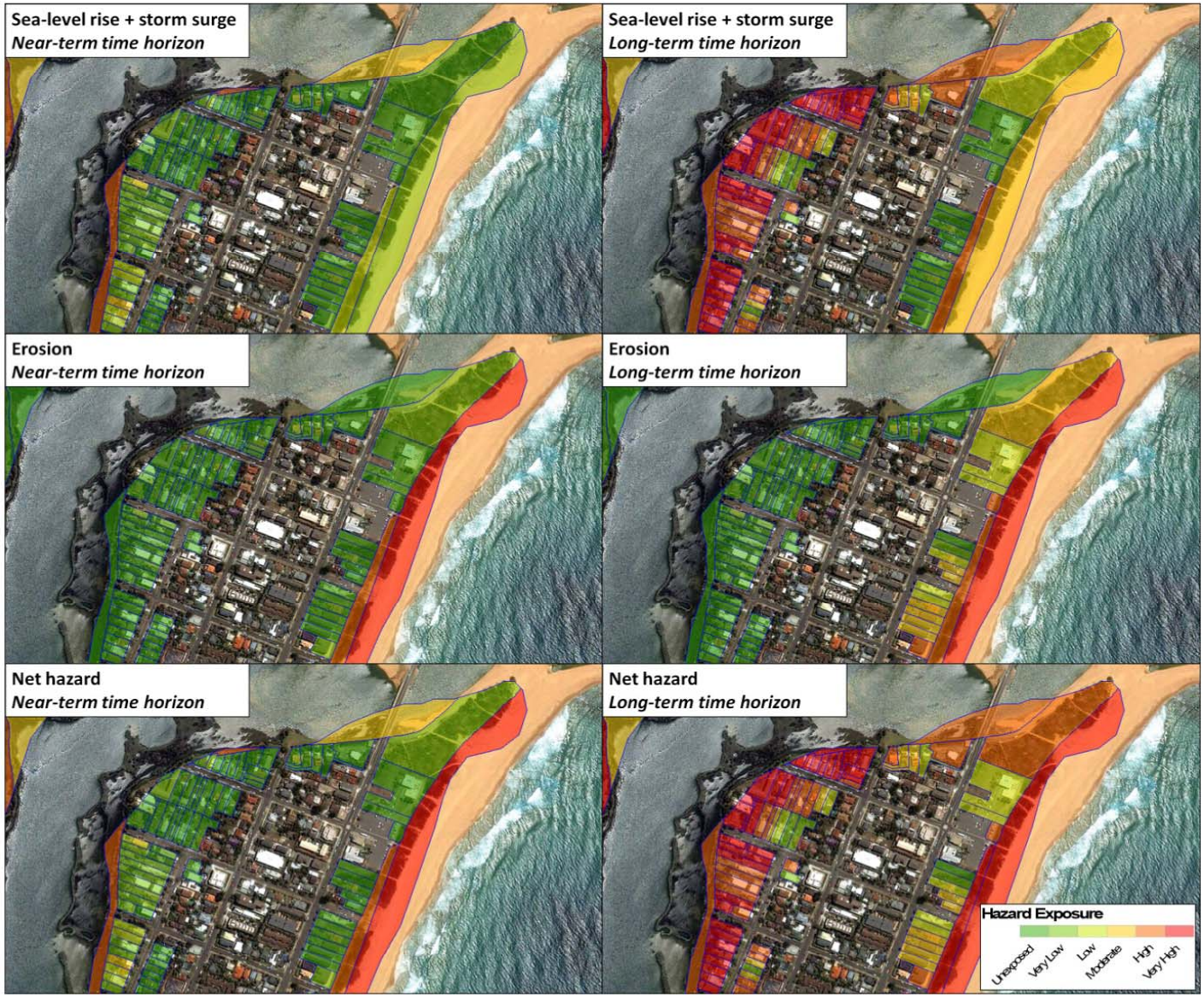


Hazard classification

- %Property Exposure = %Inundation + %Erosion

Percentage of Property Exposed	Hazard Classification
0–1%	Unexposed
1–10%	Very Low
10–20%	Low
20–40%	Moderate
40–80%	High
80–100%	Very High

Hazard classifications (Narrabean)

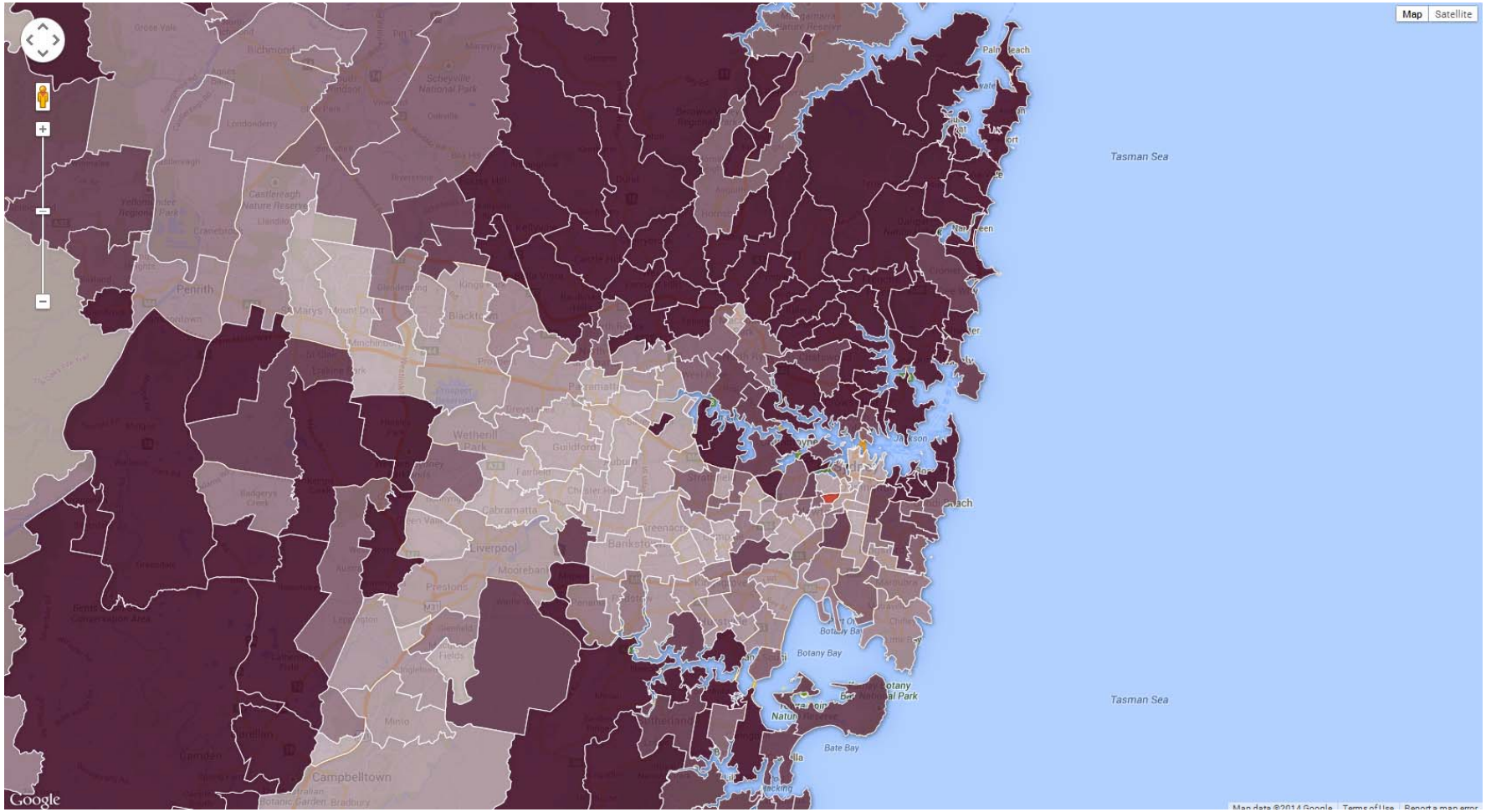


Geospatial information can be used to characterise the value of properties

Asset Category	Examples of Relevant Data Sources
Financial	• Property valuations • Density of commercial/industrial buildings • Density of transportation infrastructure • Density of water/waste water infrastructure
Social	• Density of social/community-oriented buildings (e.g.,. schools, hospitals, churches) • Recreational areas (parks, clubs, sporting grounds, recreational reserves) • Community hubs/cultural centers
Environmental	• Critical habitat areas • Density of endangered flora/fauna • Distribution of native vegetation • Distribution of natural land use • SEPP 71 areas (Sydney only) • Crown lands

Index of economic resources (2006)

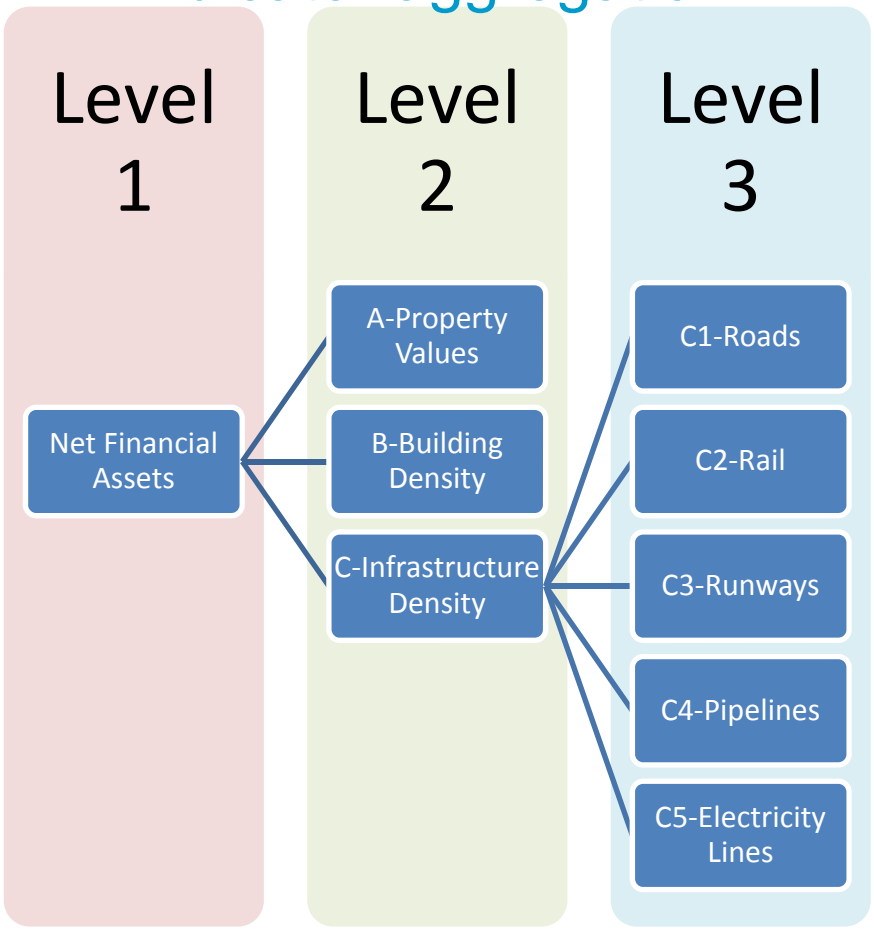
- Includes income, housing expenditure and assets of households



Developing indicators of property values

- Multiple spatial data indicators were aggregated into a net indicator for three values types (financial, social, environmental)

Indicator aggregation



Classification scheme for asset indicators

Percentage of Property Area/Indicator Percentile Ranking	Asset Classification	Numerical Score
0–1%	None	0
1–10%	Very Low	1
10–20%	Low	2
20–40%	Moderate	3
40–80%	High	4
80–100%	Very High	5
No Data	No Data	3

From hazard to risk

- Hazard information and asset density information can be used to assess risk to values

Risk Matrix

Hazard Rankings	Asset Rankings						
	No Data	None	Very Low	Low	Moderate	High	Very High
No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Unexposed	No Data	Unexposed	Unexposed	Unexposed	Unexposed	Unexposed	Unexposed
Very low	No Data	Unexposed	Very Low	Low	Low	Moderate	Moderate
Low	No Data	Unexposed	Low	Low	Moderate	Moderate	Moderate
Moderate	No Data	Unexposed	Low	Moderate	Moderate	High	High
High	No Data	Unexposed	Moderate	Moderate	High	High	Very High
Very High	No Data	Unexposed	Moderate	Moderate	High	Very High	Very High

Decision rules applied in spatial evaluation of coastal adaptation options

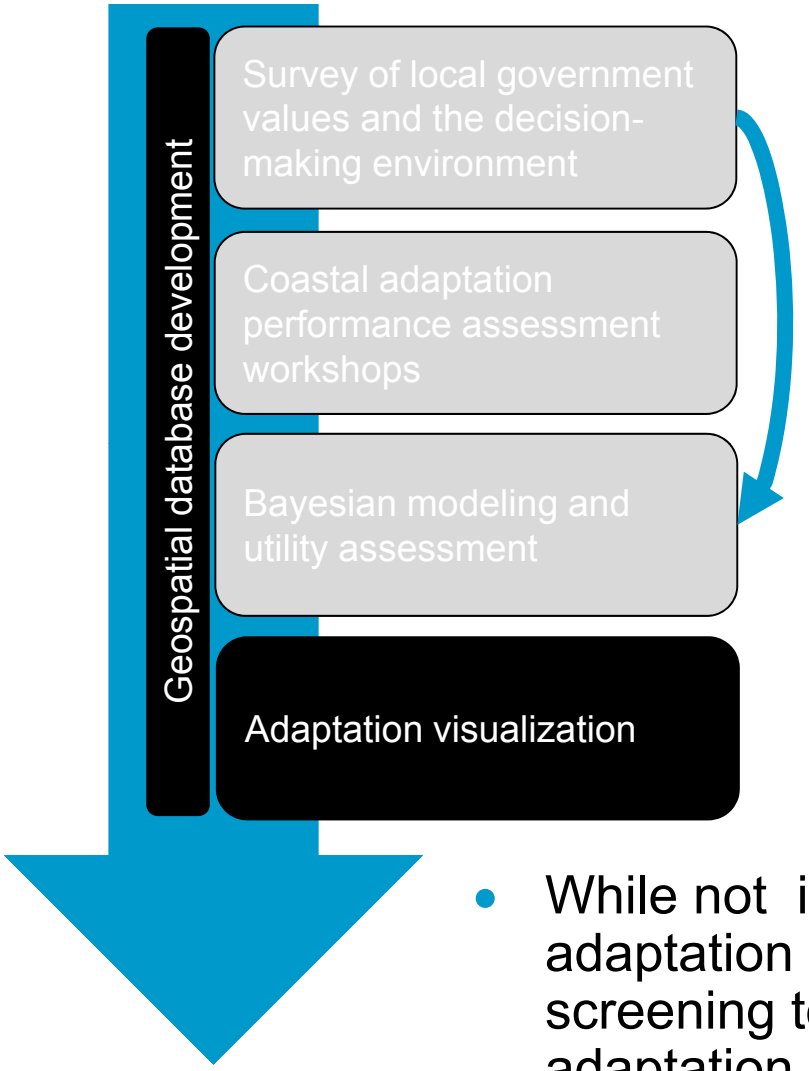
Assumption	Description
High Risk, High Reward	Adaptation options have greater utility in locations where there is a greater risk of damage or loss. This risk arises from a) exposure to hazard and b) value of assets at the location. This results in risk-based weights on those criteria pertaining to the preservation of social, environmental, or financial assets.
Between a Rock and a Hard Place	Protection measures designed to manage risks to erodible coasts have little utility for coasts that aren't prone to erosion (e.g., beaches backed by bedrock). Under such condition, the performance of relevant options is highly discounted.
Nowhere to Run	Increasing setbacks on properties for which >50% of available land is likely to be affected by coastal hazards is unlikely to be an effective strategy as available land for new structures is significantly constrained. Under such condition, the performance of increasing setback is highly discounted.
This Land is Our Land	Adaptation options on public lands are less of a threat to property rights as there is no private ownership. All options therefore perform well against the G4 criterion regarding protection private property rights if the location is public land.
Weapons of last resort	Acquisition of properties and sea walls are reserved for only those locations judged to be at very high risk and/or have significant financial assets/infrastructure. In the absence of these conditions at a specific location, the performance of these options is highly discounted.

MCA model variants

- A total of 4 MCA model variants were developed for each study region to explore sensitivity of results to subsets of criteria
- Each model was run for the three different time periods, resulting in 12 different outputs

Variant	Near-Term	Mid-Term	Long-Term
All criteria	●	●	●
Only financial asset protection criterion	●	●	●
Only social asset protection criterion	●	●	●
Only environmental asset protection criterion	●	●	●

Our methodological process



- What is the relative importance of different values in organizational decision-making?
- How important are different coastal hazards over different time horizons?
- What factors drive changes in local government policies and measures?

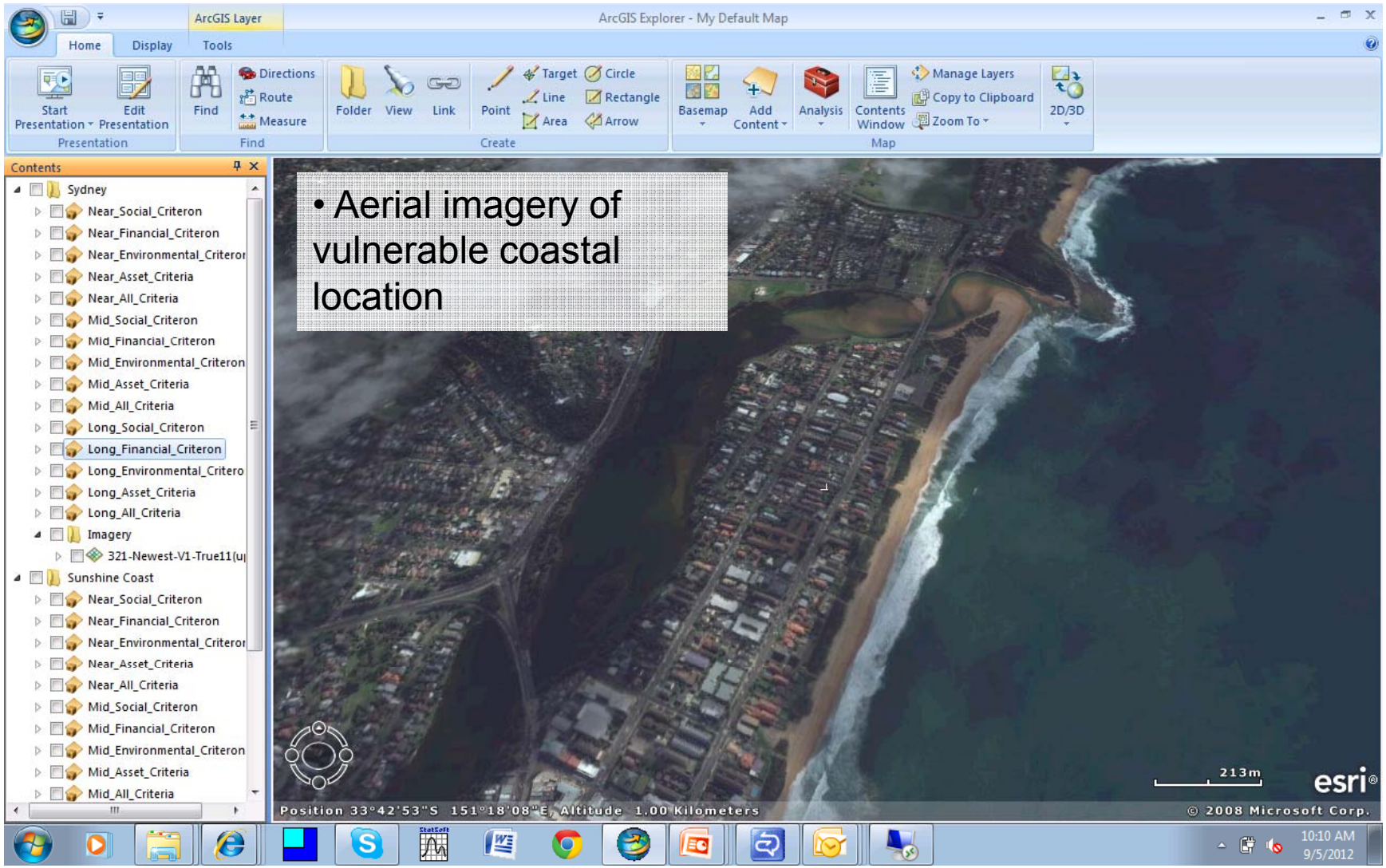
- Participatory performance assessment of different coastal adaptation options against different criteria/values (governance, financial, social, environmental) over different time horizons
- Based upon stakeholder's expertise and subjective judgment

- Development of Bayesian Belief Network (BBN) representing the conditional relationship among adaptation options and their performance
- Decision criteria weighted based upon data obtained from survey and geospatial information regarding risk to assets at the property scale
- Results in quantitative utility scores for each adaptation option
- Used to process property-specific "cases" for all at-risk properties in study regions

- Output from BBN exported to GIS environment for visualization
- Landscape imagery and HTML-enabled data layers allow for easy access to property-scale information

- While not intended to replace detailed site-specific adaptation studies, this methodology provides a screening tool and a proof-of-concept for a spatial adaptation information system

Visualising coastal adaptation at the property scale (*North Narrabean Beach*)



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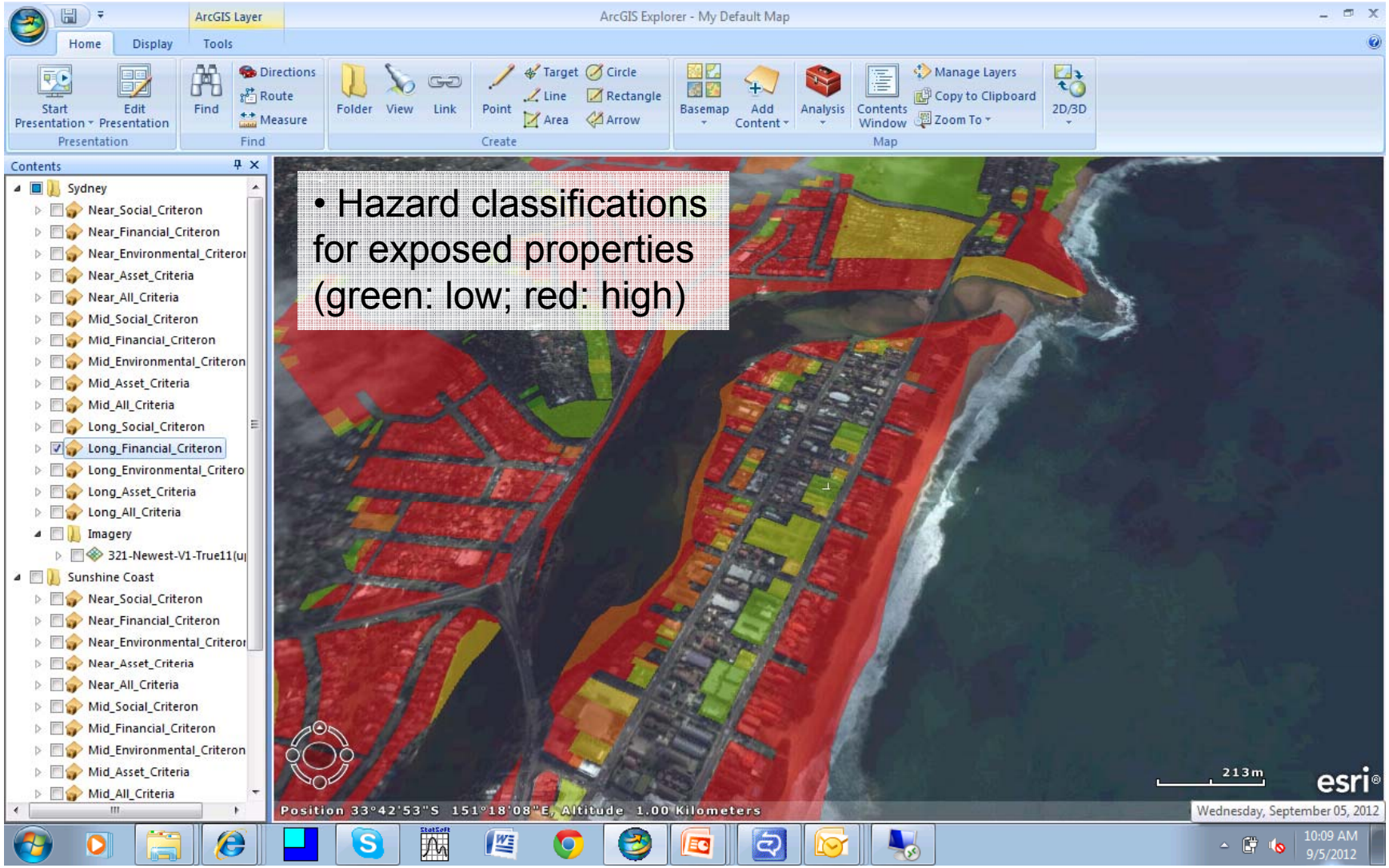
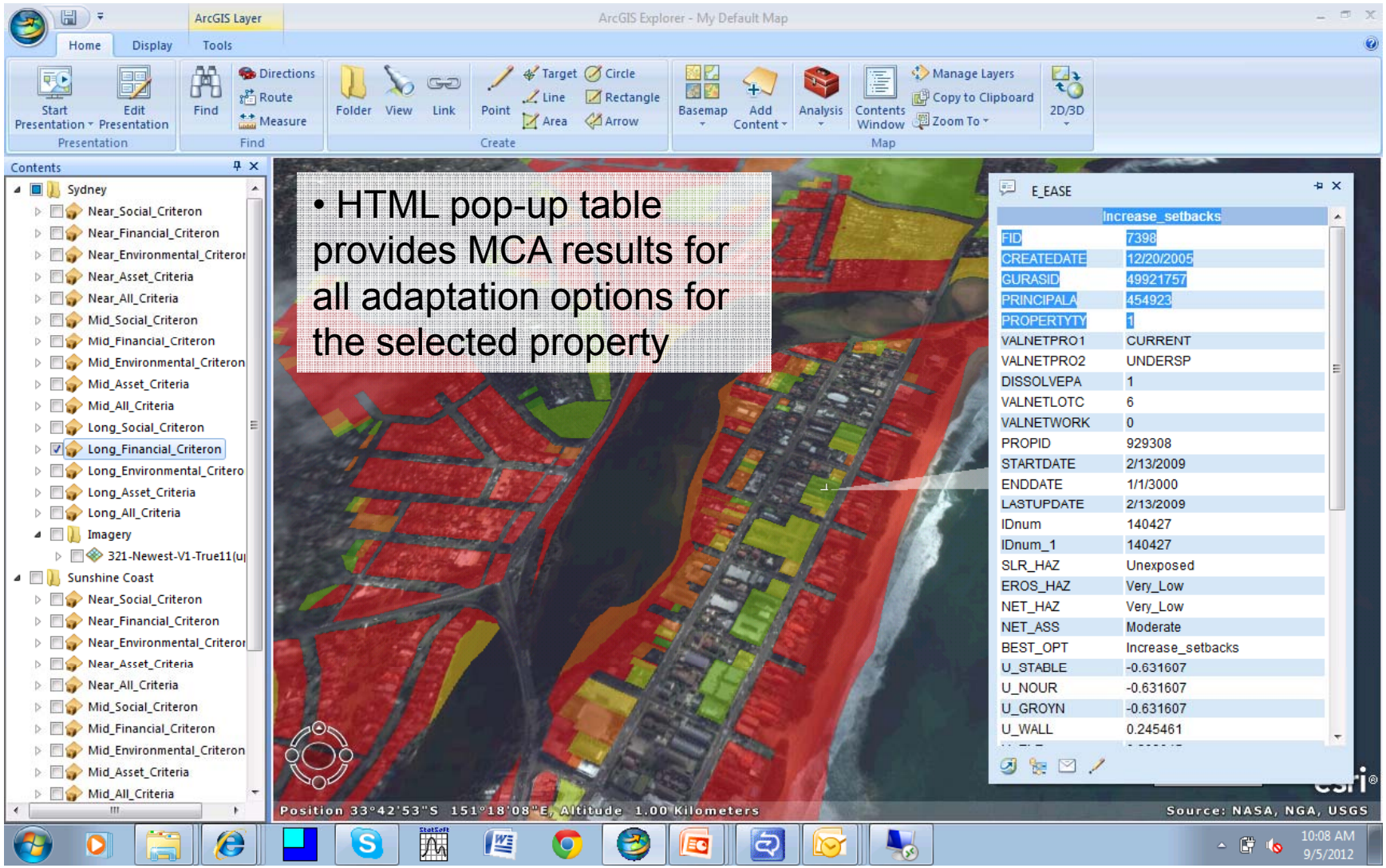
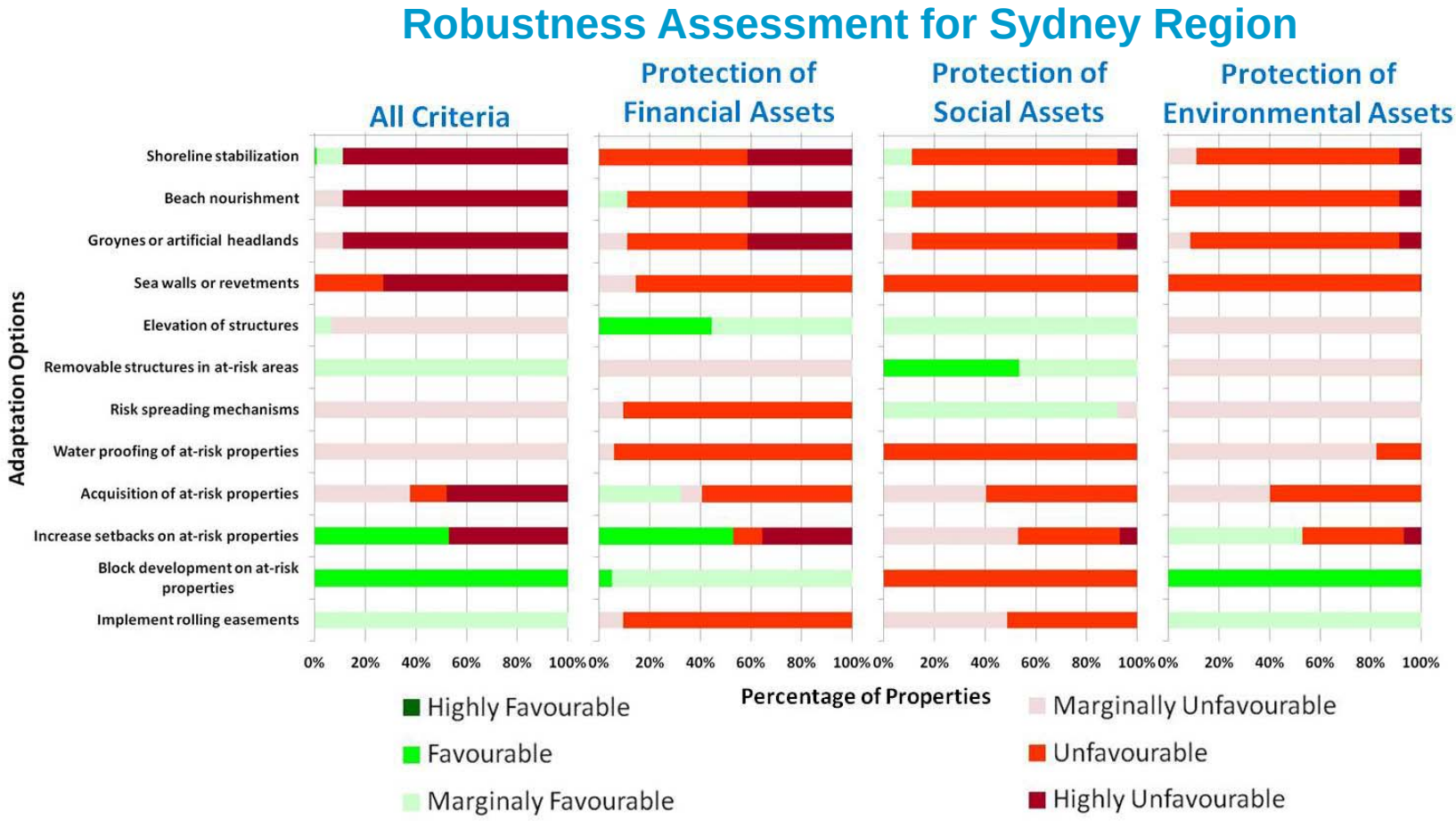


Visualising coastal adaptation at the property scale (*North Narrabean Beach*)



Identifying robust adaptation options

- 'Robust' options are those that have high utility across all model variants (i.e., satisfy social, financial, environmental criteria)



Future Development

- Our project suggests a number of useful pathways for enhancing adaptation decision-support:
  - Developing operational property-scale screening tools
    - E.g., web or mobile-device apps for real-time site-specific MCA
  - Developing more comprehensive adaptation information systems
    - E.g., use of geospatial tools to access local data bases on landscape characteristics, hazards, and management appraisal tools
- The success of such decision-support tools will ultimately be dependent upon robust monitoring and evaluation frameworks for adaptation
  - Such frameworks were developed by the University of the Sunshine Coast as part of this project

Thank You

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Definitions of Adaptation Options

Protect

1) **Shoreline stabilization** – Stabilization of existing foreshore profile and backing dunes through, e.g., revegetation

2) **Beach nourishment** – replacement of lost or enhancement of existing beach sediment from an alternative source

3) **Groynes or artificial headlines** – enhancement of local sediment through the capture of coastal sediment transported via longshore drift

4) **Sea wall or revetment** – hardened vertical or sloping structures for the protection of beaches from the effects of waves, tidal variability, erosion, and other coastal processes

Accommodate

5) **Elevation of structures** – Elevation of existing or new structures on piles and/or elevation of undelying land surface

6) **Removable structures** – Portable and/or modular structures that can be readily relocated when threatened

7) **Risk spreading mechanism/subsidisation of losses** – Provision of additional insurance mechanisms and/or subsidization of economic losses associated with coastal hazards

8) **Water proofing** – require water resistant or water proof construction on structures that may be subject to flooding

Retreat

9) **Acquisition of vulnerable properties** – buy back distressed or threatened properties

10) **Increase setbacks** – restrict new development or redevelopment to in areas of property subject to coastal processes

11) **Prevent development** – prevent development on coastal properties subject to coastal processes

12) **Rolling Easements** – prevention of shoreline protection through regulation and land tenure and allow natural coastal processes to transpire

Cross-cutting options

13) **Community education** – enhance understanding of the community and potentially vulnerable residents/businesses of coastal hazards and risk

14) **Assessment of coastal vulnerability and risk** – invest in further studies of coastal risk at varying spatial and temporal scales

15) **Integrated coastal zone management** – implement a robust ICZM approach to coastal management that includes climate change