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A systems approach to indicators

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Presentation overview

1. Brief review of sustainability assessment models from last week
2. A systems approach to sustainability
   - Ecosystem services
   - System Dynamics
   - Resilience theory
3. Systems modelling case study
4. Conclusions

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1. Brief review of sustainability assessment models

Sustainability assessment is:

A process that directs decision-making towards sustainability

[adapted from: Hacking, T and P Guthrie 2008 A Framework for Clarifying the Meaning of the Triple Bottom-Line, Integrated, and Sustainability Assessment. *Environmental Impact Assessment Review*, **28**: 73-89]

The concept of sustainability is therefore central and fundamental

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Evolution in expectations of sustainability assessment

- Minimising negative environmental, social and economic impacts of projects
- Delivering positive social, environmental and economic outcomes
- Contributing to healthy and resilient socio-ecological systems

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Sustainability as 'minimising negative impacts'

- environmental, social & economic impacts most likely to be treated separately – e.g. expert studies, predictions & mitigation
  - EIA for biophysical
  - SIA for social
- if impacts/benefits are conflicting, then trade-off decision must be made
  - to avoid unacceptable trade-offs, threshold levels must be clear
- Key issue is impact acceptability

Sustainability as 'maximising positive outcomes'

- environmental, social & economic objectives usually identified separately with no clear understanding of how they relate to each other
- if objectives conflict then will have implementation failure
- no consideration of 'bottom lines' or 'acceptability limits'

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An emerging new approach to sustainability assessment

- Minimising negative impacts of proposals (may be only environmental)

- Delivering positive social, environmental and economic outcomes

- **Contributing to healthy and resilient socio-ecological systems**

Discussion Question

How could a systems approach to sustainability overcome some of these limitations?

What are the features of a systems approach to sustainability?

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2. A systems approach to sustainability

- The world is a series of interconnected places: a complex socio-ecological system
- Behaviour of these places involves dependencies
  - between people, and
  - between people and the bio-physical environment, and
  - within the bio-physical environment

"Complex systems are composed of a large number of active elements whose rich patterns of interactions produce emergent properties that are not easy to predict by analysing the separate parts of the system."

Ostrom, E. (1999). "Coping with tragedies of the commons." Annual review of political science **2**(1): 493-535.

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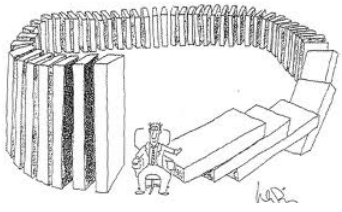
Some useful concepts and bodies of work related to systems

- Ecosystems services (e.g. Millennium Ecosystems Assessment)
- System Dynamics (causal loop diagrams & stocks and flow diagrams)
- Resilience theory



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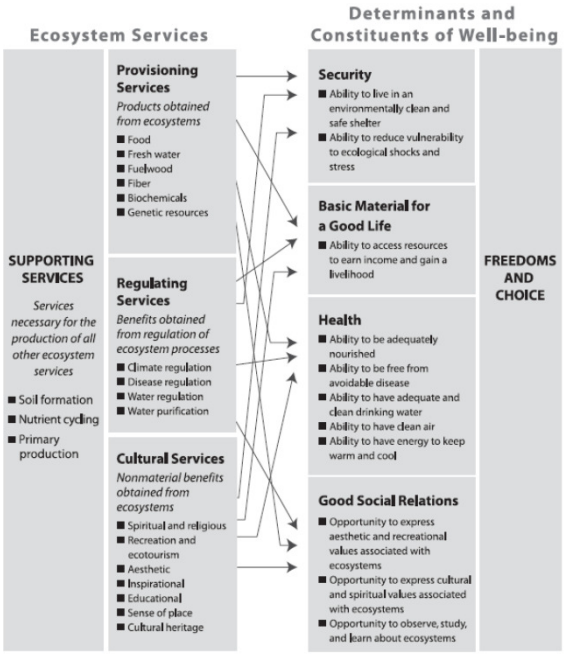
Ecosystem Services approach used in the

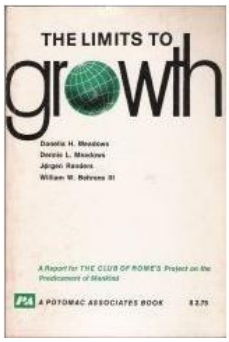
Millennium Ecosystem Assessment (2005)



http://www.millenniumassessment.org/en/Framework.aspx

System Dynamics

- Created in mid-1950s by Jay Forrester at the Massachusetts Institute of Technology (MIT)
- The MIT group was commissioned by the Club of Rome to model the global system
- Result was *Limits to Growth* (1972)
- Five variables: world population, industrialization, pollution, food production and resource depletion
- 30-year update published June 2004
- Key concepts:
  - Causal Loop Diagrams
  - Stocks and flows



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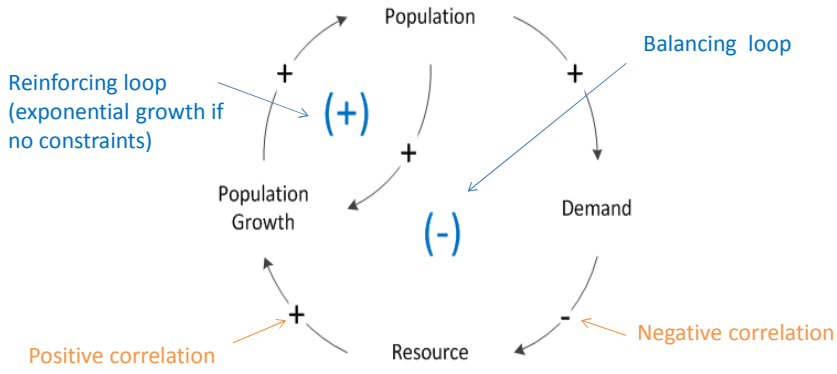
Causal loop diagrams: example



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System behaviour

- The system behaviour is driven by the rate of depletion of the resource relative to growth rate of population
- This is affected by:
  - Rate of growth of population (if too high may cause overshoot and decline)
  - Speed of balancing loop (if slow response, resource stocks are low before system comes to equilibrium, hence system stabilises at lower population)

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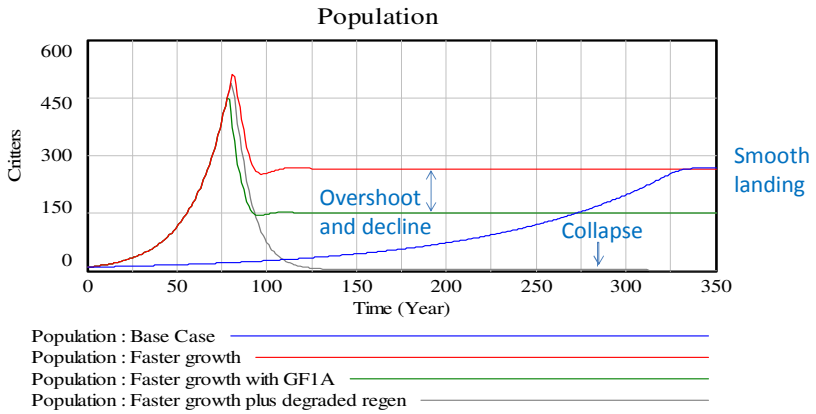
System behaviour - examples



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Resilience theory

- *Resilience is the ability to absorb disturbances, to be changed and then to re-organise and still have the same identity (retain the same basic structure and ways of functioning). It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks.*
  - The Resilience Alliance (www.resalliance.org)
- Key concepts:
  - The adaptive cycle
  - Panarchy

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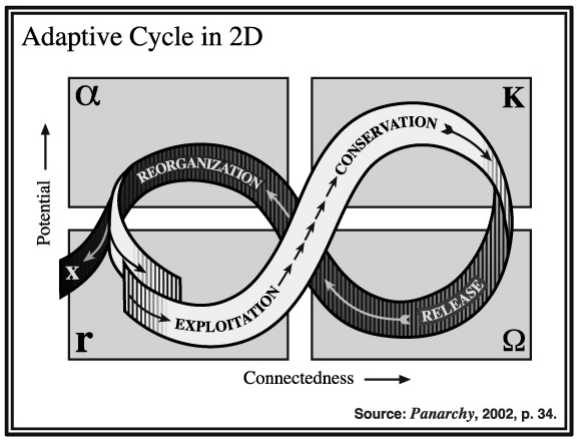
The adaptive cycle



Systems:

- Are non-linear and dynamic
- Are subject to thresholds
- Have the potential to reorganise in different forms

Gunderson, LH and Holling, CS (2002) Panarchy: Understanding transformations in human and natural systems, Island Press

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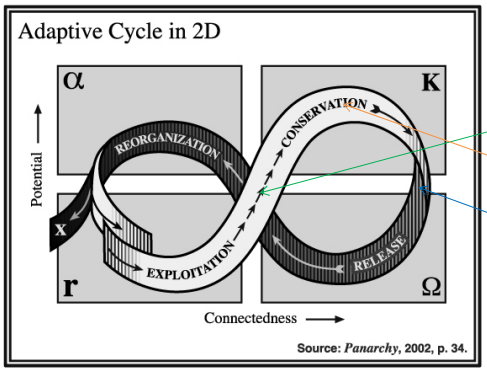
Systems dynamics and resilience theory



Growth phase

Equilibrium phase

Collapse

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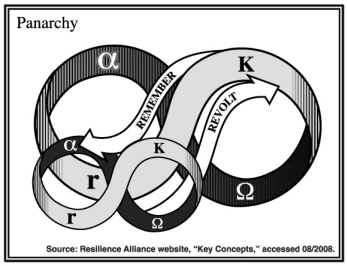
Key concept in resilience theory: Panarchy

- A system is made up of sub-systems operating at different scales and at different points in their adaptive cycles



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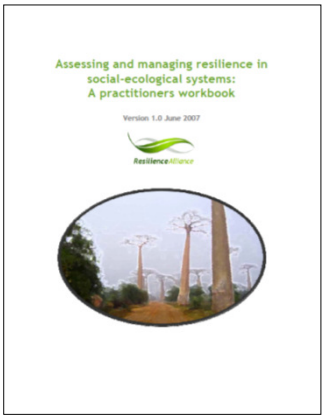
A useful tool: Resilience Assessment

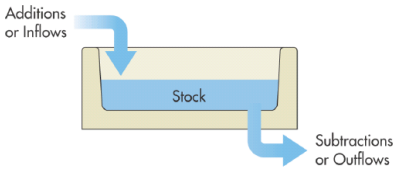


The Resilience Alliance

The Resilience Alliance. 2007. Assessing and managing resilience in social-ecological systems: A practitioners workbook. Volume 1, version 1.0. Available online [http://www.resalliance.org/3871.php].

System dynamics: Modelling system behaviour as stocks and flows

- Two types of system components:
  - Stocks
  - Flows
- Stocks are entities that accumulate or deplete over time (e.g. population and resource stock)
- A flow is the rate of change of a stock



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Social & Human Capital	Natural Capital	Economic Capital
Stocks		
Volunteering	Air quality	Household net worth
Under-empl oyment	Extent of native vegetation	Income disparity
Life expectancy	Water quality	Housing supply
Self-reported physical health	Mineral and fossil fule reserves	Productivity
Educational attainment	Timber resources	
Feelings of safety	Fish stocks	
Level of trust in core insititutions	Ground cover	
Flows		
	Greenhouse gas emissions	Vehicle and passenger kms travelled
	Waste disposed to landfill	

Some indicators may be stocks and some may be flows….
…the key issue is how they relate to each other

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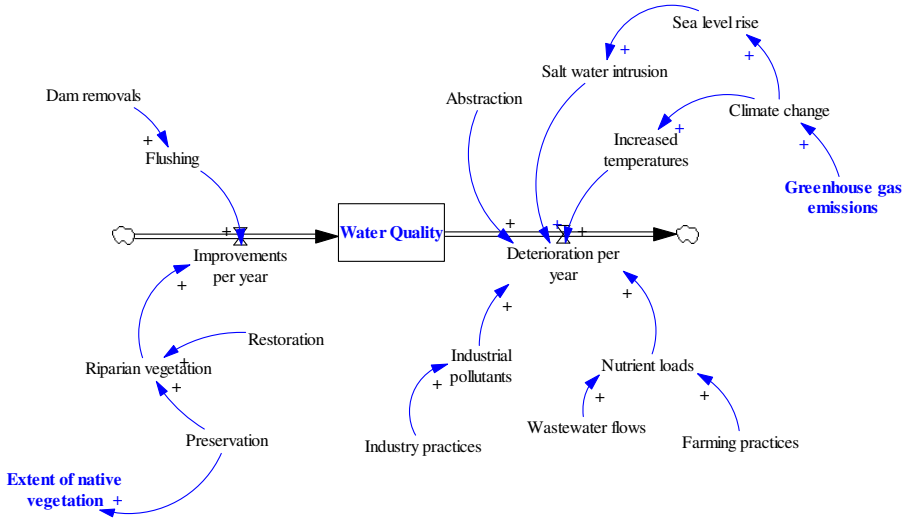
Stocks and flow diagrams shows how indicators are related (cause & effect)



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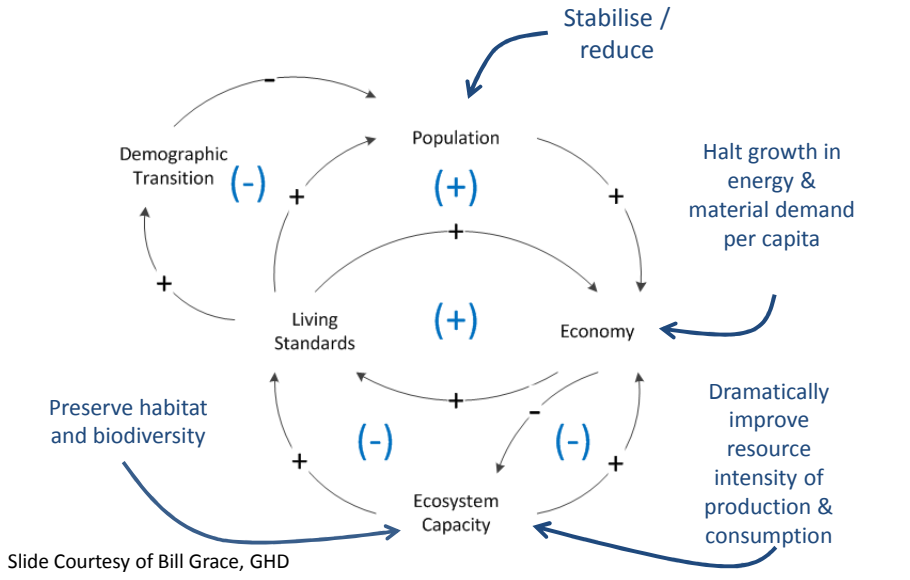
Causal loop diagrams can guide the development of meaningful objectives/indicator sets



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The problem with models!

The system dynamics mantra:

'All models are wrong – some are useful'

Slide Courtesy of Bill Grace, GHD

However models can…

- Improve mental models of cause and effect by showing interrelationship of variables
- Help process of identifying priority objectives and indicators
- Identify key leverage points
- Facilitate the construction of future scenarios
- Provide a platform for adaptive management through continual improvement of models based on evidence
- Be quantitative (using modelling software) or qualitative

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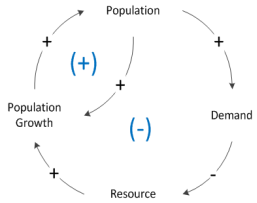
Discussion Question

In our first systems example, which components are stocks and which are flows?



Think about your sustainability indicators for the university – are they stocks or flows? Does it matter?

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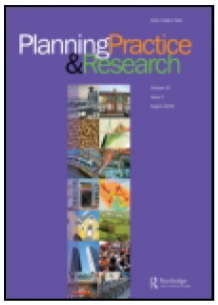
3. Systems modelling case study

Destination Modelling and Tourism Development in the Ningaloo Coastal Region in Western Australia



Planning Practice and Research
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cppr20

Regional Planning and Resilient Futures: Destination Modelling and Tourism Development––The Case of the Ningaloo Coastal Region in Western Australia

Tod Jones, Prof John Glasson, Prof David Wood & Prof Elizabeth A. Fulton

Available online: 26 Aug 2011

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Challenge: tourism development in pristine and fragile environments can cause major shifts in socio-economic and bio-physical environments, which can threaten the sustainability of a region, and make it difficult to plan for resilient regional futures.

Response: an open and collaborative approach to develop and use a model (Ningaloo Destination Model - NDM) which seeks to identify the impacts of possible development scenarios can help to build regional resilience to cope with disturbances to socio-ecological systems.

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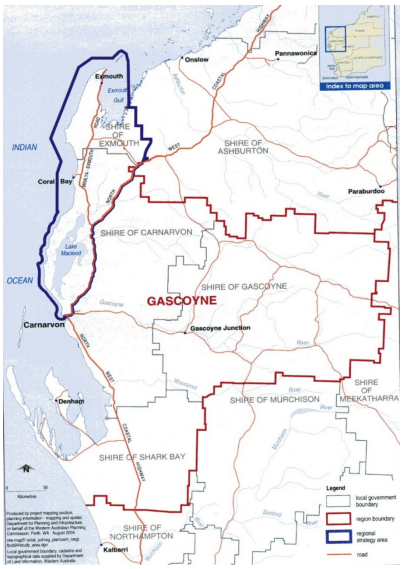

Importance of Ningaloo

Ningaloo is a 200km long fringing coastal reef – easily accessible from the shore

200 species of coral; 600 species of mollusc; 500 species of fish

including annual migration of whale sharks; and aggregations of sharks, whales and manta rays

includes some of Australia's finest marine environments – designated a 430,000ha Marine Park in 1987.

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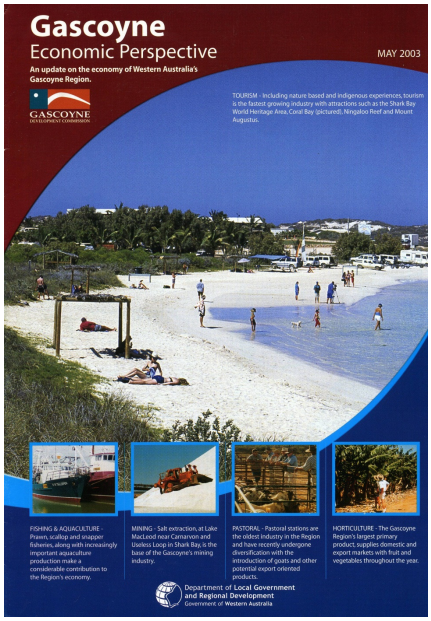
Growth, and impacts, of Ningaloo tourism

- although isolated (1200km from Perth), has been significant tourism growth since 1990
- welcomed, in context of vulnerable economic base (pastoral decline, US military pull-out)
- major locations (Exmouth, Coral Bay) and tourism activities
- environmental impacts
  - infrastructure deficiencies (water supply, sewerage capacity)
  - informal camping largely unmanaged (waste disposal issues, dune destabilisation)
  - impact on reef and fish stocks
- contested environment
  - some aggressive tourism operators
  - under-resourced Dept
  - inter-dept; and local/regional/central agency conflicts



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Coral Bay

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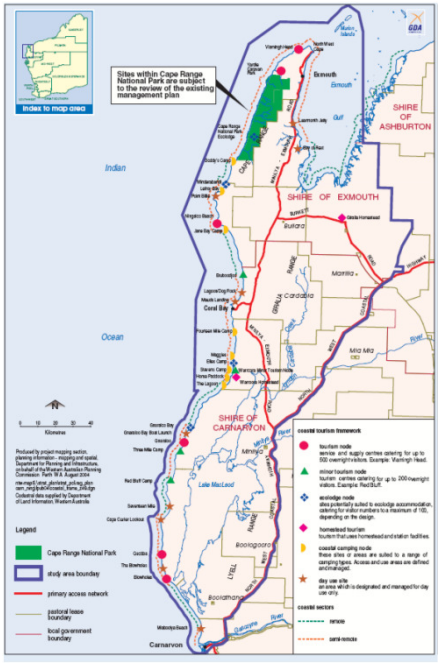

- Research project – this component undertaken by Curtin University over 2 years
- Involved engaging stakeholders in a collaborative, learning process
- Aim was to develop and use a systems model of the region (Ningaloo Destination Model)

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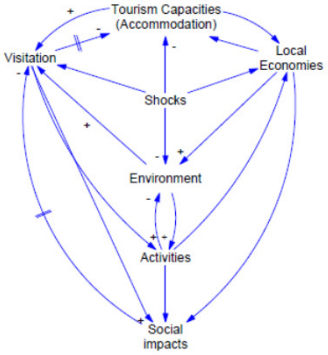
Development of the Ningaloo Destination Model

- Development of conceptual models of areas of concern:
  - Information gathered through individual meetings and compiled
  - Presented to workshops as basis for discussion
  - Feedback loops and thresholds identified
- Translation into models by quantifying relationships between variables:
  - Venisim modelling software
  - Focused on key variables
  - Data based on existing plans, published data, primary data
  - Testing against historical data
  - Linking sub-models



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Sub-models developed (i)

- **Visitor numbers and mix**: Links the visitor cycle (numbers, mix and seasonality) to other cycles in the region (weather, cyclones, marine, European visitation, holidays)
- **Residents and industry**: Addresses growth in regional industries and housing availability as determinants of population numbers and the activities undertaken by the resident population
- **Visitor activities**: Links visitor activities and experiences to tourism infrastructure, environmental quality and the characteristics of the tourism industry
- **Accommodation sector**: Addresses accommodation supply and demand in the context of land availability, investment returns, demand from other sectors and staffing
- **Visitor spending**: Uses visitor spending and economic data to calculate employment, income, value added and gross regional product

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Sub-models developed (ii)

- **Environmental loads**: Addresses water availability in the context of climate change and water consumption, waste water generation, treatment and the implications for the region's ecology, electricity demand and supply, and the potential impacts of sustainable technologies for reducing water and electricity use
- **Environmental impacts**: Links the activities of visitors and residents to a range of environmental impacts, including marine and terrestrial impacts such as coral damage, fish stocks and vegetation loss, and the monitoring of these impacts
- **Transport linkages/options**: Addresses transport to the region and within the region, including transport constraints and shocks that could disrupt travel, and links to national trends
- **Social impacts of tourism**: Identifies the positive impacts (extra facilities, regional pride) and negative impacts (crowding, incidents, dislocation) to residents' quality of life

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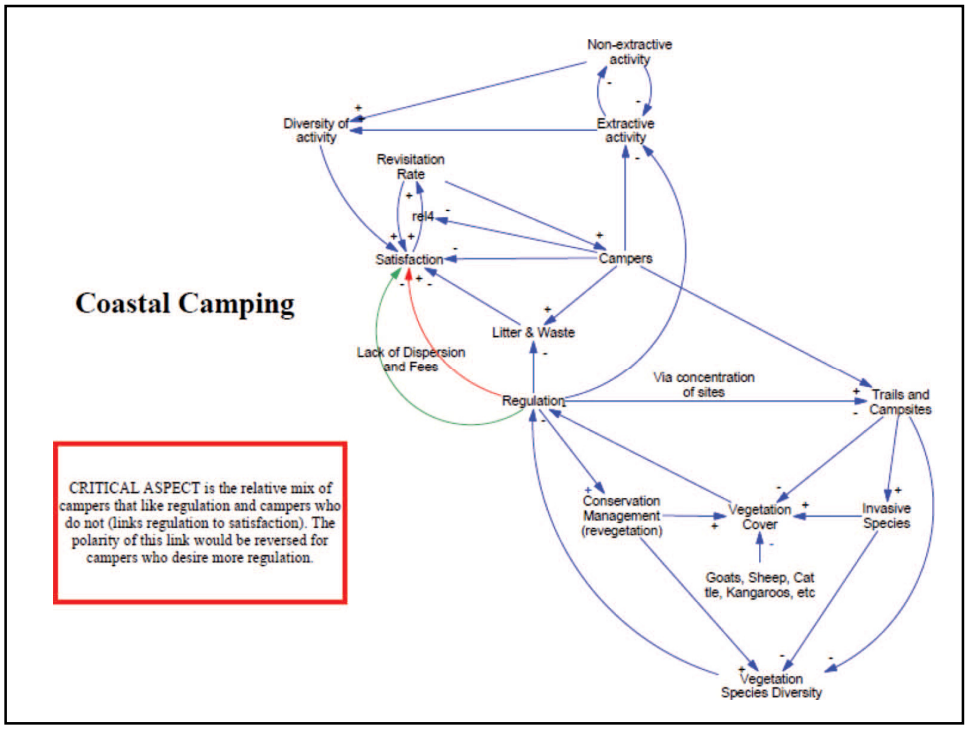
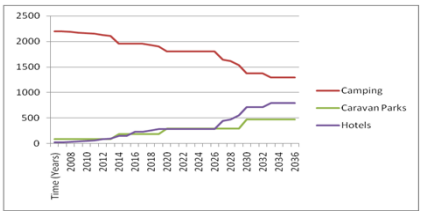
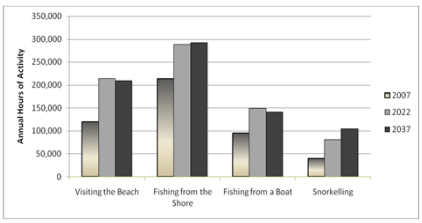
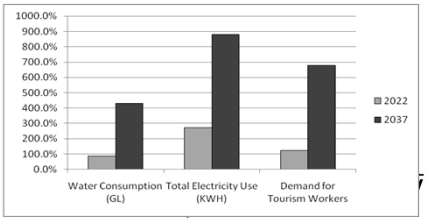


Use of the model

- Testing elements of Ningaloo Coastal Strategy (eg growth in tourist numbers, changing tourism accommodation modes)
- Undertaking specific analysis as requested by individual stakeholders
- Assessing implications for thresholds and capacities
- Ongoing input to regional planning process; vehicle for collaborative planning and development activity
- Adaptive management?







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Outcomes and lessons learnt

- Model makes significant contribution to regional planning: information and communication tool
- Linking infrastructure and development decisions with environmental, social and economic outcomes has highlighted the importance of collaboration between agencies
- Model must be flexible as planning priorities are constantly changing
- Use of model itself contributes to regional resilience
- Vital to discuss legacy and ongoing use of model with key stakeholders
- **Enables place-based adaptive management for sustainability**

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4. Conclusions

- A systems approach to sustainability:
  - Is *place-based*
  - Reflects the *dynamic* nature of systems, even existing ones
  - Shows how all the system components are related and therefore promotes *integration*
  - Enables modelling of *system dynamics and behaviour*
    - Can be qualitative or quantitative
  - Facilitates the development of meaningful *indicators*
- Useful tools and concepts include:
  - Ecosystem services
  - Resilience theory/resilience assessment
  - System Dynamics – causal loop diagrams & stocks and flow diagrams

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Discussion Question

Can you draw a causal loop diagram or stocks and flows diagram for the university?

Does it help to identify indicators?