Decision-making for climate change adaptation: a systems thinking approach

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Decision-making for climate change adaptation
a systems thinking approach

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Please cite this report as:

Maani, K 2013 Decision-making for climate change adaptation: a systems thinking approach
National Climate Change Adaptation Research Facility, Gold Coast, pp. 67.

Acknowledgement

This work was carried out with financial support from the Australian Government
(Department of Climate Change and Energy Efficiency) and the National Climate Change
Adaptation Research Facility (NCCARF).

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.

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ABSTRACT

The impacts of climate change are exacerbated by inefficient adaptation and mitigation decision making, due to the complexity of the decision-making environment. As a consequence, there is no single approach to planning and decision making. Climate change adaptation falls squarely in the domain of wicked problems that require collective learning and new modes of decision making and collaboration.

Decision making is often perceived and practiced as a linear activity, from identification of a problem to search for alternative solutions, followed by decision making and implementation. Systems Thinking and Adaptive Management, in contrast, tend to use these steps in a cyclical fashion (i.e., a feedback system). Systems Thinking, in addition, views a problem not in isolation but as part of a larger system or context. Feedback is a key concept in Systems Thinking which is formally recognised and scientifically modelled.

This report summarises Systems Thinking Tools for climate change adaptation. These tools can be used individually or in combination to provide integrative, participatory and synergistic approaches to climate change initiatives, policy design and adaptation. For users’ convenience, a Systems Thinking Tool Selection Chart is provided as a quick guide for tool selection.
1. CLIMATE CHANGE

Addressing climate change may be the most important problem the world will face in our lifetimes.

1.1 Introduction

The CSIRO and Bureau of Meteorology State of the Climate (2012, pp 3-11) reports that:

- **Australian annual average daily mean temperatures have increased by 0.9°C since 1910.**
- **Global average mean sea level for 2011 was 210 mm above the level in 1880.**
- **Sea surface temperatures have increased by about 0.8°C since 1910.**
- **The main cause of the observed increase in carbon dioxide concentration in the atmosphere is the combustion of fossil fuels since the industrial revolution.**
- **Australian average temperatures are projected to rise by 1.0 to 5.0 °C by 2070 when compared with the climate of recent decades.**

The impacts of climate change on Australia’s environment and human systems are manifold. For example, in marine and terrestrial ecosystems, species are already changing their distribution and life cycles with consequences for ecosystem health, conservation and fisheries; in agriculture, changes to climate result in reduced productivity and profitability in some locations and industries but opportunities and improvements in others; settlements have evolved and adapted to suit their climate but as the climate changes they will become more vulnerable to extreme temperatures and meteorological events such as heat waves, severe storms and floods; the wellbeing of humans is directly affected by heat and extreme weather events such as floods but also psychologically as drought and other climate related impacts bear on people’s mind (National Climate Change Adaptation Research Facility, 2012).

Two examples of climate related events that have major economic implications are drought and extreme climate events such as hail storms and cyclones. In a drought year, for example, the gross value of Australian farm production decreases by at least 10 per cent or more on average.

Over the past forty years all but one of the top 20 insured losses in Australia relate to weather or climate events, with hail, tropical cyclones, other windstorms and bushfires figuring prominently. The average cost of these events is large and not all costs are captured through insurance. Over the period 1967–99, the average annual cost of weather related disasters was estimated at $942 million. One-third of these losses were attributable to floods, 30 per cent to severe storms and 28 per cent to cyclones. The cost of insurance payouts from weather-related natural catastrophes continues to accelerate in Australia (PMSEIC, 2007).

The Australian Government has taken major strides with respect to climate change. In 2008 it commission a major study of climate change and its impact in Australia. The report known as The Garnaut Climate Change Review (Garnaut, 2008) was commissioned by the
Commonwealth, state and territory governments to conduct an independent study of the impacts of climate change on the Australian economy. The 2008 Garnaut Climate Change Review compared the costs and benefits of Australia taking action to reduce the damage of climate change caused by humans. It concluded that it was in Australia's national interest to do its fair share in a strong global effort to mitigate climate change. The Garnaut Review 2011: Australia in the Global Response to Climate Change (Garnaut, 2011) examines how developments in science, diplomacy, political culture and the economy have affected the national interest case for Australian climate change action. The report makes a range of recommendations from carbon pricing, adaptation, energy efficiency, innovation, and land and energy transformation.

1.2 Climate change adaptation

Climate change adaptation is defined as

“Actions that reduce the negative impact of climate change, while taking advantage of potential new opportunities. It involves adjusting policies and actions because of observed or expected changes in climate” (Canadian Government Report 2010).

There are generally two policy approaches to deal with climate change, namely, adaptation and mitigation. Adaptation refers to “responding to climate impacts” while mitigation deals with “reducing GHG emissions”. In other words, adaptation is reactive while mitigation is preventative. According to IPCC, both adaptation and mitigation measures are required in order to significantly reduce climate change impacts. However, these measures sometimes produce conflicting options that require trade-offs. For example, biofuel is seen as an alternative source of energy. However, planting for biofuel may require clearing of forests which reduce the absorption rate of GHG, or the use of scarce agricultural land which would increase poverty in less developed countries.

1.3 Challenges for climate change adaptation

The inherent uncertainty in climate change is exacerbated by the complexity of decision-making environment which is caused by the number of the institutions involved and the stakeholders affected, and the frequent policy changes, changes in regulations, election of new leaders, changes in national government staff, as well as NGO and local community demands and influences. Owing to these dynamic changes, the decision makers and stakeholders are faced with new priorities, challenges, and problems as well as fresh opportunities. Thus the challenge is finding new ways to manage uncertainty and complexity in this environment and to create a consensus on how to move forward. It is for these types of complex environments that new decision making tools and models are required (Belton and Stewart, 2001).

As involved stakeholders approach this task with divergent views, backgrounds, assumptions and values, the key challenges for management and policy people is to first create a collaborative mindset and a sense of “common good” amongst the participants. This will facilitate development of a shared understanding of the complexities underlying decision making in climate change adaptation. In this relation, Newell and Proust (2012, p.18-19) warn:

“A collaborative effort will have a variety of impacts on the mind-sets of the collaborators, and the eventual effect on their behaviour can be slow to appear. This is particularly true when the aim is to mesh a range of mental models and observational data. Even if the participants in such an endeavour express satisfaction with their progress, and can demonstrate a significantly increased understanding and
acceptance of each other’s point of view, it is difficult to know to what extent the resulting systemic policies are reliable. It is essentially impossible to demonstrate that they are anywhere near the optimum.”

Complexity and uncertainties inherent in adaptation decision making include (NCCARF, Project Brief, 2011):

- inevitable trade-offs between different parties, either between costs and benefits or between beneficiaries and those who suffer detriment;
- the need to include economic, social and environmental factors
- inherent uncertainty at virtually all levels of analysis, from future climate conditions and impacts to the cost, effectiveness and benefits of adaptation investments;
- a wide range of possible time scales from immediate, for extreme events, to decadal, for incremental changes to ambient climate conditions;
- a wide range of spatial scales at which investment, planning and management may be applied and benefits gained or detrimental impacts experienced;

1.4 Complex (Wicked) Problems

Climate change adaptation falls squarely in the category of wicked problems. From both scientific and social view points, this is a ‘new’ challenge requiring collective learning and new modes of decision making and collaboration. Thus, decision making for climate change adaptation is a complex and dynamic process.

The notion of ‘wicked’ problem was first introduced by Horst Rittel in the 1960’s. However, Buchanan’s definition is most frequently cited (1992):

“A class of social problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing”.

This notion has recently gained considerable attention and rigorous scientific treatment from the emerging field of Complexity Science. Wicked (complex) problems do not lend themselves to conventional expert-driven, single-focus and top-down approaches with assumptions of rationality and anticipation of quick and narrow solutions.

Here, the imperative for partnership at every level is paramount – between private and government, local and federal, national and global, poor and rich, powerful and the disadvantage. This is a human-kind challenge, demanding new levels of cooperation and partnership unlike any in our collective history. The response must be also be collective moving us forward towards new and deeper forms of interacting and social learning.

1.5 Pitfalls in Decision Making

The decision science literature provides rich research on dynamics of decision making and pitfalls thereof. In this regard, a well-cited array of papers has dealt with counter-intuitive and counter-productive decision making in complex systems (see for example Meadows 1972, 1992; Morecroft, 1983; Keating et al., 1999; Repenning & Sterman, 2001). Another strand of research deals with the notion of Bounded Rationality, which maintains that even with the best information and intentions, most decisions do not result in favourable outcomes as anticipated by decision makers (Simon, 1987). This is attributed, among other factors, to limited information processing ability (Morecroft, 1983, 1985), erroneous mental models (Senge 1990, Li and Maani, 2012) and misperception of feedback (Sterman, 1989, 2000). The decision making task becomes even more complex when decisions require consensus and agreement of several stakeholders with divergent agendas, goals and motivations.
Further, empirical studies show most individuals lack the capability and inclination to deal with complexity. This is because human mind has basic physiological limitations that makes it unable to adapt to slow changing conditions, of conforming to group and organizational norms, and of focusing on repetitive activities (Miller, 1956; Van de ven, 1986).

1.6 Adaptive Management and Decision Making

Decision making is often perceived and practiced as a linear activity following simple steps of problem > research > Information > decision > implementation. Adaptive Management (AM), in contrast, tends to use these steps in a cyclical fashion (i.e., a feedback system). Adaptive management is commonly used in natural resource management (NRM) interventions. This is because decision making in NRM environments is far from optimum and experimentation and learning are core parts of NRM decision making. The challenge inherent in AM, especially in policy and NRM settings is the presence of long ‘feedback’ delays which could often take years if not decades for outcomes to emerge. This poses a serious constraint on AM effectiveness.

Feedback is also a key concept in Systems Thinking which is formally recognised and scientifically modelled. As we will discuss later in this report, combining systems thinking and experimentation is the foundation of the learning cycle. Learning cycle is conceptually similar to adaptive management, except that by using computer simulation tools (System Dynamics) or micro worlds, decision makers can experiment in a virtual environment and thereby drastically shorten the feedback cycle. This removes the key weakness of AM and facilitates group learning and shared understanding - two critical pre-conditions for complex problem solving such as climate change adaptation.

1.6.1 Decision Making and Planning for Adaptation

There is no single approach to planning and decision making for adaptation. This task varies from location to location and country to country as it is influenced by government structures, legal systems, geography and national culture, and stage of economic development.

According to Black (2010), at the local and community levels

“Most climate change adaptation actions are embedded in a municipality’s existing plans and strategies. In some communities, municipal staff and community partners have developed plans, policies, regulations or programs specifically for climate-change adaptation. These plans may target one adaptation issue/measure or be wide-ranging by tackling numerous climate issues, cross-cutting various departments and even external organizations. Such planning can target private citizens, including home and business owners, or be focused on a municipality’s internal operations and infrastructure.”

1.6.2 Key ingredients for successful adaptation planning

Extensive research and practice has identified five requirements for successful adaptation to climate change. These are summarized below (Black 2010):

1. Understanding and assessing vulnerability – Understanding a municipality’s climate vulnerability provides a basis for establishing priorities where stakeholder input is critical.
2. Managing risk – Vulnerability assessments are a common element of risk management which helps selecting the best course of action in uncertain situations and assists decision-makers to understand, analyse and communicate potential risks.
3. Climate Change Scenario thinking – Scenarios can help raise awareness of climate change risks and help plan to address specific impacts. Scenarios complement
projections of socioeconomic changes that many communities use as part of long-term planning processes.

4. Identifying synergies and overcoming conflict – “Understanding the links between climate change actions and sustainability goals helps municipalities make their adaptation actions more effective by strategically allocating resources to achieve multiple outcomes. Decision-makers also need to be aware of the various agendas and possible conflicts that can arise when choosing adaptation measures.”

5. Awareness, leadership and partnerships – Leadership for multi-stakeholder partnerships and collaboration is critical for addressing the complex challenges of climate change.

The decision-making tools presented in this report, address the above elements for climate change adaptation success. The successful implementation of adaptation measures is to a large part a function of the decision making process employed. In this relation the participation and input from all stakeholders is an essential ingredient in the decision making process and the implementation success (Tauzin Jamal et al. 2004).

1.7 Understanding decision makers & stakeholders mindsets

Climate change adaptation decision making and management involves a large array of stakeholders including individuals, community groups, NGOs, local and national governments, scientists and business and industry groups. In order to effectively engage with decision makers in climate change adaptation, it is imperative to appreciate and consider the mindsets and motivations of the concerned decision makers and stakeholders. This will help lessen or alleviate potential resistance to change and adaptation. To this end we identify the following as key drivers for adaptation decisions. These drivers and motivations are not mutually exclusive and could well have overlaps.

- **Personal** drivers – this reflects deep personal beliefs and worldviews re climate change. A vivid example here is the deep-seated belief on the large part of the inhabitants (mostly elderly) of Tuvalu that based on the promise to Noah in the Old Testament, God will not send another major flood. This was the response to the scientific warnings that the Island/atoll nation will soon submerge as a consequence of rising seas.
- **Organisational/institutional** drivers – this is a crucial and influential group at the heart of decision making for climate change adaptations. The potential resistance and barriers to adaptation form this group can come from a lack of deep understanding and appreciation of complexity and inherent uncertainty imbedded in climate change adaptation. This ‘conceptual’ or ‘perception’ challenge is exacerbated by long time frames inherent in climate change.
- **Political** drivers – this represents political and governmental agendas that drive national and global policies and politics. These are the most influential drivers which often overshadow the common good and impede consensus decisions and systemic actions by all parties.

1.8 Decision Makers for Climate Change Adaptation in Australia

The following groups are key decision makers for Climate Change Adaptation in Australia:

- The Commonwealths Government (national policy)
- State and local governments (local policy, regulations, etc.) – this is the most relevant group
- Business and Industry (national and local) – very influential group but more difficult to engage, at least in the short term
Other stakeholders – in addition to the above, there is a vast number of institutions, as well as the public who have a stake in climate change adaptation. These include the academia/scientists, NGOs, SMEs and other interested or affected groups whose size, voice and influence will grow over time as climate change adaptation impacts becomes more apparent and the need to adapt more urgent.

The final arbiter for climate change adaptation effectiveness is a transformative change and genuine realisation and respect for the common good for all humanity. In this context, national self-interests and myopic solutions will be detrimental to all. It is in this spirit and context that systems thinking offers the approach and promise of a holistic solution. This will be underpinned by a collective will and openness for learning leading to consensus decisions and unified actions.
2. SYSTEMS THINKING

Systems Thinking is a scientific tool and language for understanding complexity and creating consensus within multi-actor decision environments. The NCCARF project brief states (pp. 8-9):

“Systems thinking can help integrate social, economic and environmental factors which can help decision makers to understand all implications of their decisions and make trade-offs. Systems thinking approaches have been widely used to support planning and management decisions in Australia, but have not been tested to any great extent in supporting climate change adaptation decisions”

There are many definitions for Systems Thinking. According to Wolstenholme (1997), Systems Thinking can be viewed in the following ways:

“What: A rigorous scientific approach to help thinking, visualising, sharing, and communication of the future evolution of complex systems and issues over time;

Why: for the purpose of solving complex multi-stakeholder problems and creating more robust designs, which minimise the likelihood of unpleasant surprises and unintended consequences;

How: by creating conceptual maps and simulation models which externalise mental models and capture the interrelationships of physical and behavioural processes, organisational boundaries, policies, information feedback and time delays; and by using these architectures to test the holistic outcomes of alternative plans and ideas;

Within: a framework which respects and fosters the needs and values of awareness, openness, responsibility and equality of individuals and teams”

Richard Tait, the chief advisor for strategy development in New Zealand’s Ministry of Economic Development, comments on the benefits that a systems thinking approach can provide in the modern public policy environment:

“I have found that a very pragmatic and ‘soft’ approach works best with my colleagues. I help them understand the need to take a systems thinking perspective on complex problems. Causal loop diagrams (CLDs) can be used as a way of creating a more effective conversation around the nature of the problem and the relationships between relevant factors.”

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2.1 Systems Thinking Tools for Decision Making

In this section Systems Thinking tools for climate change adaptation decisions are discussed under different categories shown below. These tools can be used individually or in combination to provide integrative, participatory and synergistic approaches to climate change initiatives, policy design and adaptation. A summary of these tools is provided below so that users could select the most appropriate tool without having to learn about all tools in detail. Following this summary, each tool category is discussed in detail and examples illustrated.
2.1.1 Systems Thinking Tools Summary

Systems Thinking Tools for Climate Change Adaptation can be categorised in five broad groups as follows. A list of individual tools and when to use them is shown in Tables 1 and 2 below.

1. Problem Framing and Scoping Tools
   - **What:** for understanding and agreeing on the nature and scope of the problem/s
   - **Who:** all key stakeholders
   - **When:** the initial stages of problems solving/decision making
   - **Why:** climate change adaptation problems are often multi-dimensional, ‘ill-defined’ and far from clear. Often problem symptoms are mistaken for its root causes
   - **Potential Pitfalls:** too many participants and hidden agendas. Need gentle facilitation

2. Qualitative/Conceptual Tools
   - **What:** to identify problem drivers and map out their dynamic interconnections
   - **Who:** key decision makers, stakeholders, subject matter experts (SMEs)
   - **When:** for systemic understanding of problem drivers and barriers and their causal interrelationships; for identifying influential variables where hard data is not available or relevant
   - **Why:** decision makers have a tendency for ‘jumping into solution’ without fully understanding the underlying causal factors and their dynamics
   - **Potential Pitfalls:** Some participants may be uncomfortable with lack of hard data. Need expert facilitation

3. Quantitative Tools
   - **What:** to quantify decision outcomes and expected patterns of behaviours of key variables and their relationships
   - **Who:** expert modellers, key decision makers, select stakeholders, subject matter experts
   - **When:** for quantitative modelling of problems and quantifying underlying relationships and patterns of behaviour
   - **Why:** policy makers/scientists often require hard data for decision making
   - **Potential Pitfalls:** long and expensive model development; over reliance on model and its outputs. Need expert facilitation.

4. Scenario thinking/planning tools
   - **What:** to think through plausible scenarios and possible futures in regards to climate change adaptation and their implications for interventions
   - **Who:** key decision makers and planners, scientists, key stakeholders
   - **When:** highly uncertain situations where historical data is absent and untested assumptions are prevalent
   - **Why:** climate change adaptation is fraught with uncertainty and untested assumptions

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Potential Pitfalls: inconclusive outcomes; scenario outcomes could erroneously be viewed as forecasts or predictions. Need expert facilitation.

5. Organisational Learning

What: for enhancing groups, teams or organisations’ decision making capacity and collective intelligence and performance.

Who: diverse groups including decision makers, planners, scientists and stakeholders

When: for creating shared understanding of complex problems and thorny issues where consensus decisions and common vision are critical

Why: most decision making processes deal with surface problems and do not delve into deeper issues masked by hidden agendas and divergent mental models.

Potential Pitfalls: time commitment; desire to find quick solutions; discomfort with holistic approach. Need expert facilitation.

Table 1: Tool Selection Guide

<table>
<thead>
<tr>
<th>Tools</th>
<th>Recommended Reading</th>
<th>When to use it?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Framing and Scoping Tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Qualitative/Conceptual Tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Soft System Methodology</td>
<td>Checkland P. (1989)</td>
<td>Identifying problem scope and boundaries</td>
</tr>
<tr>
<td>• Cognitive mapping</td>
<td>Eden &amp; Ackermann (2001)</td>
<td>Linking disparate concepts related to a key issue</td>
</tr>
<tr>
<td>Tools</td>
<td>Recommended Reading</td>
<td>When to use it?</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Quantitative /Probabilistic Tools</strong></td>
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<td></td>
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<tr>
<td></td>
<td>Sterman J. (2000)</td>
<td>dynamic systems</td>
</tr>
<tr>
<td><strong>Scenario thinking/planning tools</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Scenario planning</td>
<td>Maani &amp; Cavana (2007)</td>
<td>-Group think for visualising alternative future</td>
</tr>
<tr>
<td></td>
<td>Scenario planning resources</td>
<td></td>
</tr>
<tr>
<td>- Microworlds</td>
<td>Maani &amp; Cavana (2007)</td>
<td>-Simulation models for testing alternative futures</td>
</tr>
<tr>
<td><strong>Organisational Learning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Mental Models</td>
<td>Senge P. (1991)</td>
<td>-Understanding deep motivations, values, assumptions and cultures of diverse</td>
</tr>
<tr>
<td></td>
<td>Senge, P. et al (1994)</td>
<td>stakeholders and decision makers</td>
</tr>
<tr>
<td>- Learning Labs (LLab)</td>
<td>Maani &amp; Cavana (2007)</td>
<td>- Rigorous process of collective learning and consensus building</td>
</tr>
<tr>
<td>- Collaborative Conceptual Modelling (CCM)</td>
<td>Newell &amp; Proust (2012)</td>
<td>- a framework for integrating qualitative and quantitative systems tools</td>
</tr>
</tbody>
</table>
Table 2: Tool Application Guides

<table>
<thead>
<tr>
<th>Problem Framing Tools</th>
<th>Workshop Time</th>
<th>Development time (Post workshop)</th>
<th>Ease of learning application</th>
<th>Required data (software)</th>
<th>Facilitator required? (post training)</th>
<th>Scope of applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich Picture</td>
<td>1-2 hrs</td>
<td>Nil</td>
<td>Easy</td>
<td>Mental (n/a)</td>
<td>No</td>
<td>Wide</td>
</tr>
<tr>
<td>Affinity Method</td>
<td>2-3 hrs</td>
<td>2-3 hrs</td>
<td>Easy</td>
<td>Mental (n/a)</td>
<td>No</td>
<td>Wide</td>
</tr>
<tr>
<td>Soft systems methodology</td>
<td>3-8 hrs</td>
<td>1-5 days</td>
<td>Medium</td>
<td>Mental (n/a)</td>
<td>Depends on the scope</td>
<td>Wide</td>
</tr>
<tr>
<td>Benefit/Required Time Ratio</td>
<td>Very high</td>
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<thead>
<tr>
<th>Conceptual Modelling Tools</th>
<th>Workshop Time</th>
<th>Development time</th>
<th>Ease of learning application</th>
<th>Required data (software)</th>
<th>Facilitator required? (post training)</th>
<th>Scope of applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Maps</td>
<td>2-3 hrs</td>
<td>2-3 hrs</td>
<td>Medium</td>
<td>Qualitative (n/a)</td>
<td>No</td>
<td>Wide</td>
</tr>
<tr>
<td>Causal Loop Diagrams</td>
<td>2-3 hrs</td>
<td>2-3 hrs</td>
<td>Medium</td>
<td>Qualitative-Soft (Vensim)</td>
<td>Depends on the scope</td>
<td>Wide (development time increases with variable size)</td>
</tr>
<tr>
<td>Benefit/Required Time Ratio</td>
<td>Very high</td>
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<table>
<thead>
<tr>
<th>Quantitative/Simulation Tools</th>
<th>Workshop Time</th>
<th>Development time</th>
<th>Expert knowledge required</th>
<th>Required data (software)</th>
<th>Facilitator required? (post training)</th>
<th>Scope of applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBN</td>
<td>3-8 hrs</td>
<td>3-5 hrs</td>
<td>Expert knowledge required</td>
<td>Probabilistic &amp; Qualitative (Netica, etc.)</td>
<td>Yes</td>
<td>Medium (development time increases with size)</td>
</tr>
<tr>
<td>System Dynamics (SD)</td>
<td>3-8 hrs</td>
<td>Few days to few months, depending on the scope</td>
<td>Expert knowledge required</td>
<td>Quantitative &amp; Soft (Ithink, Vensim, Powersim)</td>
<td>Yes</td>
<td>Limited (development time increases with variable size)</td>
</tr>
<tr>
<td>Benefit/Required Time Ratio</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

2.2 **Problem Framing and Scoping Tools**

In individual or group decision making, it is commonly assumed that the ‘problem’ is known and well understood by all concerned. This assumption tends to cause the decision makers to instantly search for and *jump* into ‘solutions’. This often leads to counter-effective outcomes – often with adverse consequences. This is because *obvious* problems are often symptoms of deeper causes and hence *obvious* solutions only serve as quick fixes, leading to new problems. This is shown below:

![Figure 1: Problem solving approach](image_url)

In contrast, Systems Thinking seeks to uncover the underlying causes of the problem and to create a shared understanding of the problem situation for all concerned, before searching...
for solutions. This places the emphasis on not only the solution content (technical), but the all-important context (i.e., organisational, social, political) within which the problem manifests itself and the solution plays out.

The diagram below illustrates the Systems Thinking approach.

\[ \begin{align*}
\text{Problem} & \quad \Rightarrow \quad \text{Understand the system that causes the problem} \quad \Rightarrow \quad \text{Identify Leverage Points} \quad \Rightarrow \quad \text{Change the system}
\end{align*} \]

**Figure 2: Systems Thinking approach**

The systems approach can be more precisely shown via a “systems” diagram shown below. This represents a correcting or “balancing” feedback process whereby changes in the system would remove or minimise not only the symptoms but the root causes of the problem.

\[ \begin{align*}
\text{Problem} & \quad \Rightarrow \quad \text{System is changed} \quad \Rightarrow \quad \text{Understand the system behind the problem} \quad \Rightarrow \quad \text{Identify leverage point(s) for change}
\end{align*} \]

**Figure 3: Systems Approach Problem Solving Loop**

In the following sections, constructing systems models is explained in detail. The systems tools discussed below will assist decision makers to deeply understand and agree on the nature and scope of the problem and decide collectively how to move forward. It is assumed throughout this report that the participants in decision making process comprise the decision makers/stakeholders discussed in earlier sections.

### 2.2.1 Rich Picture

Rich picture is a pictorial, cartoon-like representation of a problem situation. Rich pictures are particularly useful where the stakeholder/participants are not comfortable or confident with the ‘spoken’ language or where there is no common language amongst the participants. This situation commonly arises in working with indigenous groups or in countries where scores of tribal languages and dialects are used. In such cases, other forms of expression such as sand drawing is effective and appropriate.

An example of a rich picture developed for a systems thinking and modelling intervention is shown below (Figure 4).
Figure 4: Rich Picture for a Makara Farm Woodland

(Source: Cavana, et al, 1996, p.183)
2.2.2 The Iceberg Model – Four Levels of Thinking

The Iceberg model, aka the Four Levels of Thinking (Maani & Cavana 2007), is a generic and powerful framework for viewing a problem at deeper levels. This model is shown below:

Figure 5: Iceberg model
(Adapted from Maani & Cavana 2007)

The event level describes the incidents and 'happenings' that alert us to a problem situation. This is what we often refer to as ‘the problem’. Events attract immediate attention and often demand speedy action, or immediate reaction, like an accident, a flood or famine.

The next level down is patterns, which describe the history of events or trend of data over time. Patterns provide deeper and richer information, like the history of floods and fires. The third level, systemic structures, describe the interaction amongst drivers and factors that cause ‘the problem’ and lead to observed patterns and events. For example, the combination of human decisions (building a dam, managing water discharge, land use and agriculture) and natural factors (heavy rain, soil condition, flora and fauna) could cause or exacerbate floods. The fourth level of thinking is mental models which refer to deeper ‘human factors’ such as beliefs, world views, feelings and motivations that underlie and affect all human decisions and actions. This is the level that causes wars and tragedies as well as lofty enterprises and praiseworthy human deeds.

Commonly, the actions and policies of organisations and discourses of society tend to focus on the events and ignore deeper causal levels. This leads to short term fixes with unintended and adverse consequences. Thus, a clear distinction and formal consideration of these levels is crucial in effective decision making.

2.2.3 Pattern Analysis – Behaviour over time (BOT)

Behaviour over time (BOT) is a simple and practical tool to reveal the ‘history’ of a problem or situation, such as a draught, a bush fire, an accident (oil spills), etc. BOTs also capture social and political phenomena like incidents of crime, policy compliance, voter’s confidence, etc. BOT is a graph of a variable against time where the variable is plotted on the Y axis and Time is shown on the X axis. A variable can be an actual or historical data (e.g. rain falls, bush fires, draughts) or, in the absence of factual data, it can be based on expert opinion or best ‘guess’ or even their perception. The collective creation of a BOT allows the participants to ‘harmonise’ their perception of the problem and to create a shared understanding of the extent and severity of the situation. Hence BOTs serve as an effective tool for problem structuring and understanding.

While it is important to capture measurable or ‘hard’ data, all too often, the deeper drivers and influencers of a complex system are ‘soft’ and obscure. Soft or intangible variables such
as trust, quality of relationship, confidence in others, attitude towards partnership and collaboration play a key role in decisions outcomes and their sustainability. They act as an ‘invisible web’ that connects and holds all the pieces together. They can make or break a system – as sophisticated as the global financial system. Hence, to tell the full story of a complex situation it is necessary for the participants to share and capture relevant ‘soft’ variables on BOT graphs.

Figure 6 shows two examples of BOTs in relation to climate incidents and a community’s capacity to respond.

![Figure 6: BOT Examples](image-url)
2.2.4 Affinity Method for Anonymous Brainstorming

One of the key steps in decision making is to identify and agree on the real problem at hand. This sounds deceptively trivial and simple. That is why, too frequently, decision makers assume they know and understand ‘the problem’ and hence immediately embark on finding the solution. Sometimes, the problem is even couched in solution terms. For example, “the problem is we need more staff”, or “the problem is we need more communication”.

In reality, however, complex problems such as climate change adaptations (and often non-complex problems) evade simple solutions. This is because these problems have manifold dimensions and multiple stakeholders who may see the problem partially or differently. For example, in a case of river water quality, engineers, city planners, farmers, scientists, citizens and the industry noted different views on what contributed most to water pollution and flow (Wedderburn, 2012).

Thus a crucial first step is to create a shared understanding of the problems and the issues at hand. Sometimes, the deeper reasons for the problems are disguised and would not be spoken about openly. For example, farmers may not want to adhere to a new policy re carbon emissions simply because this would increase their workload and burden their lifestyle. The government could try their hardest to make farmers comply with the policy, but unbeknown to the reasons for their resistance or lack of compliance.

To this end, the process and methodology described below seeks to create a forum for surfacing the issues impacting a decision situation. While it has become commonplace to engage stakeholders in open and participatory decision making, such methods often fall short of their potential to create breakthrough or sustainable outcomes. This is, by and large, due to the way these methods are conducted and how information is gathered from the participants. Generally meetings where people verbally share their views and ideas are fraught with politics and hidden agendas which prevent people from speaking their mind. Thus, most participants take a safe ‘sitting-on-the-fence’ approach and withhold personal information or real objections to avoid ‘rocking the boat’, offending others, or fear of exposing oneself. Consequently, this will permit a few outspoken or forceful individuals to dominate the proceedings. The meeting outcome is commonly a list of action items which can be characterised as polite, shallow and rather obvious.

2.2.5 Issues identification

Before the Workshop

1. Identify key issue/s of interest to the group and management (e.g., lack of collaboration, lack of compliance, low productivity, etc.)

2. Identify people/stakeholders who should be at the workshop (as a general rule, the more representative and diverse the group the better. 15-25 is a good number for the workshop)

3. Articulate one (or two) rich questions based on the key issues identified above (e.g. What are the drivers and barrier to collaborations …..?). Note that for each question the full workshop process would take 2-3 hrs to complete. A climate change related workshop question would be:

   What are the drivers and barrier to an equitable carbon tax which is acceptable by all parties concerned?
2.2.6 Workshop Process

1. Review the workshop Question/s with the whole group to make sure it sits comfortably with all present. If required, adjust some wordings of the Question (however the essence of the Question should remain intact).

2. Divide the participants into groups of 3-4 people. Again diversity is important.

3. Display the final Question on a PPT (and give a hard copy to each group).

The Affinity Method (AM) or KJ (after Japanese anthropologist Jiro Kawakita) (Maani & Cavana, 2007), is a silent group brainstorming technique based on ‘similarity’ grouping of semantic data. The steps of Affinity Method are outlined below:

1. Each participant will answer the Question individually and in SILENCE. Each answer is written on a separate Post-it note (yellow).

2. After all members of the group have completed their individual answers, they spread their Post-it notes randomly on a flat surface (wall, window, white board, etc.)

3. Groups then ‘sort’ all anonymous responses in SILENCE into similar columns or clusters. Each column must represent a unique concept or idea. Here, it is important that individual notes (issues) should not be force fitted into any columns, as they may lose their unique concept. To this end, single item columns (called lone wolves) are permitted.

4. Once sorting is completed each group will discuss and select a ‘label’ for each column. These labels represent a summary or average of group’s collective and creative thinking.

5. In this step, the labels generated in step 7 are used as variables and are converted into a systems map (Causal Loop Diagram). A systems map is an integrated picture of collective thoughts and ideas. Systems mapping is a powerful tool that unifies divergent thoughts and mental models and facilitates trust and consensus decisions. Thus, systems mapping process and output can add significant new insights to the shared understanding of issues. This step can be performed post workshop with a select group of representatives.

Development of systems maps (Causal Loop Models) is covered under qualitative/conceptual modelling later in this report.

2.3 Qualitative/Conceptual Tools

2.3.1 Soft systems Methodology (SSM)

Soft Systems Methodology (SSM) was developed by Professor Peter Checkland (1989) at Lancaster University (UK) as a framework and methodology for dealing with multi-stakeholder and ‘ill-defined’ problems. SSM is based on the premise that “human and organisational factors cannot be separated from problem solving and decision making” (Pidd, 1996: 122).

According to Pidd (1996: 132), SSM follows seven stages as follows and depicted in Figure 7:

1. The problem situation is unstructured.
2. The problem situation is expressed.
3. Root definitions of relevant systems are identified.
4. Conceptual models are developed.
5. The problem situation (stage 2) and the conceptual models (stage 4) are compared.
6. Feasible and desirable changes are considered.
7. Action is taken to improve the problem.”

The above stages begin with a ‘vague’ problem in stage 1 which is explored and depicted in the form of a rich picture in stage 2. In stage 3, the participants attempt to identify root causes of problem. This leads to a conceptual model of the problem (stage 4), which can use a variety of modelling tools including causal mapping, process flowchart, cause and effect (fishbone), etc. In stage 5 the model is validated by the stakeholders as a true representation of the problem. Once the model is validated, alternative changes (solutions) are proposed and evaluated in stage 6. Stage 7 is where agreed changes are implemented.

SSM philosophy has close affinity with the principles of total quality management (TQM) and in particular the Seven-Step or the Plan-Do-Check-Act (PDCA) methods of (Shiba et al., 1994). In particular, the focus of SSM on root cause definition provides a powerful learning process for groups and organisations (Maani & Cavana 2007).

Figure 7: Soft System Methodology Framework
(Adapted from Checkland 1981 in Maani & Cavana, 2007)

2.3.2 Cognitive Mapping

Cognitive maps are tools for group thinking and problem solving. Cognitive mapping was developed by Eden and Ackermann (Eden et al., 1983; Eden and Ackermann, 2001; Ackermann and Eden, 2001) as tool for visualising a complex situation

Cognitive Mapping, similar to SSM, considers people’s mindsets and problem’s contexts as important parts of ‘problem solving’. Thus, a key premise of Cognitive Mapping is that
“desirable outcomes are the product of both content and process (i.e. the end and the means). This means that, in organisations, the effectiveness of policies and strategic plans depends not only on the plan itself or the apparent results, but also on how the plans are arrived at, as this determines people’s commitment to organisational plans and decisions.” (Maani & Cavana, 2007 P.24)

The core elements of cognitive maps are ‘concepts’ which are “generated during an interview process using the words used by the interviewee” (Pidd, 1996, p152). Using common knowledge or causal logic, the concepts are connected together by arrows to form a cognitive map. Figure 8 shows an example of a cognitive map for a sustainable tourism situation.

Figure 8: Example of a Cognitive Map for Sustainable Tourism
(Source: Copland, et. al, 2004, p.50)
While cognitive maps and causal loop diagrams, (described in detail under Qualitative/Conceptual Tools section) may appear visually similar, yet they are distinct conceptually and methodologically (Richardson, 1999).

“...used in cognitive mapping are phrases that often contain comparative adjectives (e.g. better, bigger, fewer, less). On the other hand, the ‘variables’ used in causal loops are nouns that have ‘quantities’ associated with them (e.g. demand, supply, quality, motivation, etc.). [Further], the linkages in cognitive maps are not ‘closed’ and hence feedback loops tend not to arise in cognitive maps. In contrast, in causal loop diagrams, feedback loops are the mainstay of the method, indicating dynamic and recurring patterns.” (Maani & Cavana, 2007 P.26)

2.3.3 Strategic Options Development

Regardless of the tools described in this report, group commitment and buy-in are essential pre-conditions for successful and lasting outcomes. Strategic Options Development and Analysis (SODA) is another tool that facilitates group think and commitment and has a focus on action. SODA methodology is based on the premise that

“In order for people to work as a team and create a shared understanding, it is essential that they should be jointly involved in problem definition and the search for ways to solve problems (i.e. strategy formulation). SODA methodology moves people through a process of debate and negotiation towards a joint commitment to action.” (Pidd, 1996, p.157)

2.3.4 Causal Loop Modelling: Mapping the System

Causal loop modelling is a tool for mapping a set of relationships forming a ‘system’ – such as a policy, a strategy or a regulation. The end result is a ‘picture’ showing causal links amongst key drivers or influential variables which affect the system’s behaviour or outcomes. Thus, a causal loop diagram (CLD) reveals the systemic relationships (structures) underlying a complex system.

In relation to the four levels of thinking, in addition to revealing the systemic structure (3rd level of thinking in the iceberg model), the causal loop modelling process will surface the mental models (assumptions, values, perceptions) of the participants and decision makers that drive their motivations and behaviour.

The variables used in a CLD can be quantitative (hard/measurable) or qualitative (soft). While ‘soft’ variables, such as trust, confidence, and collaboration do not generally lend themselves to direct measurement, nevertheless, their inclusion adds considerable power and realism to the model.

In a CLD, the variables are linked together by arrows. An arrow (link) between two variables indicates a causal relationship, or direct influence or change. For example, climate change increases high winds which bring deeper waters with high carbon contents to the surface. This reduces ocean’s absorption rate of carbon causing rising temperature of the earth’s surface – hence, global warming.

This causal chain is shown by a high-level CLD as well as a detailed causal loop in Figure 9 below.
A causal link between two variables implies polarity or the direction of change between the cause and effect pairs. In general, there are two scenarios:

1. the two variables change in the Same direction - denoted by (S) or (+) on the arrow
2. Or they change in Opposite directions – denoted by (O) or (-) on the arrow

That is, the polarity is ‘S’ when two variables move up or down together and polarity is ‘O’ when one variable moves up while the other moves down, and vice versa.

For example, in Figure 9 above the link between climate change and high winds over oceans indicates change (or movement) in the same direction. In contrast, an increase in surfacing of deeper waters (with high level carbon) reduces the carbon absorption rate of the ocean – hence it is a change in opposite direction. In relation to the interpretation of a causal link Richardson (1997, p.249) comments:

“It should be noted that causal loop diagrams use one symbol for two ideas: an arrow can represent a ‘causal influence’ (e.g. a policy or information link) and an arrow can represent an addition to or subtraction from an accumulation (e.g. a physical process).”

The polarity between two variables can change over time and under varying conditions. This is due to the nonlinear nature of most variables in natural, bio-physical or social systems. For example, dieting and weight loss are often associated together, i.e., more dieting, more weight loss. However, this relationship can change due to an individual’s body metabolism which sets a ‘limit’ to weight loss from dieting alone.
2.3.5 Feedback Loops

Where a causal loop is closed (not all CLDs are closed loops), it forms a feedback loop. A feedback loop represents a special dynamic (pattern) which provides deeper insights into the behaviour of a system. There are two types of feedback: (1) reinforcing, and (2) balancing. Reinforcing feedback indicates a self-propelling dynamic which underlies continuous growth or decline patterns. In contrast, balancing feedback is about stability and reaching targets (goal seeking).

Balancing loops are common in social and natural systems. In governance and organisational systems, balancing loops take the form of rules, regulation and policies. They are also abundant in natural and biological systems.

‘Blood alone contains hundreds of chemicals – oxygen, carbon dioxide, water, salts, sugars, enzymes, fats, minerals, hormones, etc. – each of which is regulated by one or more loops … Other natural and social systems depend on negative feedback just as much for their survival” (Kauffman, 1980, P.12)

2.3.6 Reinforcing feedback

Reinforcing feedback represents positive feedback systems which characterise growing or declining patterns. The difference between growth and decline is only a matter of direction – where growth denotes upward spiral while decline implies a downward spiral. Figure 10 (a) illustrates a reinforcing (growing) dynamic between climate change and global warming. Similar reinforcing patterns exist between interest and savings balance, motivation and performance, exercise and health, and so on. Figure 10 (b) illustrates a reinforcing dynamic between cost of non-renewable energy and renewable energy adoption.

It should be noted that, generally, beyond a certain level (or point in time) growth is constrained or slowed down by other forces (i.e., a balancing loop) which in some cases could inhibit or ‘crash’ the growth, hence the adage ‘nothing goes up for ever’.
Depending on the initial condition of variables, a reinforcing loop can also produce a decline pattern, which represents a downward movement or spiral.

**2.3.7 Balancing feedback**

Balancing loops represent ‘negative’ feedback that resist or counteract change. In contrast to reinforcing loops, a balancing loop aims for stability. Hence rules, regulations and policies are ‘balancing’ mechanisms that are ‘expected’ to bring ‘control’ or stability to a system.

In a climate change scenario, as shown in the CLD example below (Figure 11), higher levels of carbon emissions trigger and “motivate” government action to introduce incentives for renewable energy use, which over time (with some delay) would reduce carbon emissions. Reduced levels of carbon emission relax government propensity to intervene further, leading to increased levels of carbon emissions. And so the cycle repeats. This dynamic produces a sine curve pattern for carbon emissions similar to that shown in Figure 11.

In policy and regulation design and implementation, it is important to note that the ‘delay’ (lag) between action and response has a significant effect on a balancing feedback and the timing of its effects. In general, delays cause fluctuations and prolong the time it takes to reach desired outcomes.
Figure 11: A Balancing loop and behaviour pattern it generates

**Group Model Building – Fast Track Method**

1. Each group to consult and choose one issue, challenge, or problem
2. Brainstorm on key variables that affect your selected issue (10-12) variables
3. Draw BOT graphs for key variables (5-6)
4. Create a CLD for the issue
5. Is there an archetype present in the story?
6. Where is the leverage in the system?
7. What intervention strategy/ies do you recommend?

### 2.4 Quantitative/Probabilistic Tools

#### 2.4.1 Bayesian belief networks (BBN)

Bayesian belief networks (BBN) is a group decision making tool based on probability theory. BBN is especially effective where expert knowledge is uncertain, ambiguous, and/or incomplete and where many decision makers and stakeholders are present.

Bayesian network algorithm uses conditionals probabilities for each variable to calculate the joint probability distribution for all variables in the network. For a more detailed description of Bayesian networks see Spiegelhalter, et al (1993).

"Bayesian network model is represented at two levels, qualitative and quantitative. At the qualitative level, a directed graph [is used] in which nodes represent variables, and directed arcs describe the conditional independence relations embedded in the model."
At the quantitative level, the dependence relations are expressed in terms of conditional probability distributions for each variable in the network. Each variable X has a set of possible values called its state space that consists of mutually exclusive and exhaustive values of the variable. For each variable a table of conditional probability distributions is specified, one for each configuration of states of its parents.” (Nadkarni and Shenoy, 2004).

The following case describes a BBN application for a participatory development of a framework for risk trade-offs decision making under climate change for the Great Barrier Reef (GBR) (Adapted from Thomas, et al 2009).

In this case study, the BBN model was developed to integrate various dimensions of the Great Barrier Reef social-ecological system (Figure 12). The model helped decision-makers understand the trade-offs associated with creating resilient reef communities to deal with future climate change threats. The threats were caused by increasing surface ocean temperatures which triggered severe coral bleaching with flow-on adverse effects on water quality within the GBR lagoon. Improving the lagoon water quality required rigorous catchment management with considerable cost to the agricultural sector. However, this cost would be offset by increasing tourism revenue. The purpose of the BBN model was to develop a scientific platform for understanding these trade-offs and decision making by key stakeholders.

To simplify the modelling task, key components of the system, namely, agriculture and tourism sectors were focused on and cross linkages were developed to create an integrated systems model. This resulted in a large number of alternative solutions, each with its own set of trade-offs across the system. The final BBN model facilitated the cost-benefit analysis of these trade-offs within a risk assessment framework and helped decision makers to prioritise alternative actions.

BBN models rely heavily on historical, experimental or expert data. Here, a mix of empirical, simulated, and subjective data were derived for each sector. A key advantage of the BBN process is its ability to resolve data uncertainties in a transparent fashion. This includes estimating error terms for alternative trade-off scenarios which makes trade-off uncertainties explicit and provides decision-makers with a quantitative framework to resolve catchment level questions and dilemmas.

Some of these questions raised in the case were (Thomas, et al 2009):

- “Which reef protection target provides the lowest risk and maximum benefit for the local community?
- How soon must reef protection targets be realised in order to maximise cross-sector benefits?
- Can win/win strategies be pursued with acceptable levels of certainty?
- For a given reef protection target, what are the costs to industry and how are they distributed across sectors?
- What are the risks and benefits of maximum and ‘do nothing’ reef protection targets, and how are these risks and benefits distributed?
- Are the economic benefits to tourism likely to be large enough to balance economic losses to agriculture?
- Are economic losses in any sector likely to exist at levels that substantially reduce community wellbeing?
- What are the most influential system components, and are they amenable to policy development?”
Once a BBN model is developed and verified, it can be extended to incorporate other dimensions of the system such as the effect of land use on water quality and tourism. In all cases the model structure and assumptions should be validated by the stakeholders and modelling facilitators.

### 2.5 System Dynamics

System Dynamics (SD) is a powerful scientific methodology for simulating complex systems and to observe and test their dynamic behaviour. SD can be viewed as the ‘quantification’ of casual loop models. The System Dynamics Society define SD as

“A methodology for studying and managing complex feedback systems. Feedback refers to the situation where $X$ affecting $Y$ and $Y$ in turn affecting $X$ perhaps through a chain of causes and effects. Only the study of the whole system as a feedback system will lead to correct results.” ([www.systemdynamics.org](http://www.systemdynamics.org))

Sterman (2000, p. 4) offers a learning oriented definition of SD:

“System Dynamics is a method to enhance learning in complex systems.”
System dynamics is interdisciplinary in nature as its scientific roots, namely, nonlinear dynamics and feedback concepts can be found in mathematics, physics, and engineering. As SD deals with human behaviour as well as bio-physical systems, it also draws on cognitive and social psychology, economics, and other social sciences.

2.6 Stock & Flow Concepts

System dynamics modelling is based on the Stock and Flow concepts. These concepts are mathematical parallels of integration and derivation respectively. In other words, Stock represents accumulation while Flow denotes the change in the level (state) of a variable. Examples of stocks are CO\textsubscript{2} levels in atmosphere, amount of nitrate in soil, population, level of confidence, etc. Examples of flows are emissions, absorptions, births/deaths, production, etc. As flows represent change over time, they are measured and expressed as per unit of time, such as rain fall per day, birth per year, production per week, etc.

SD models are constructed and run in specialised computer software (the commercial ones include iThink, Vensim, and Powersim). In the iThink computer software (www.iseesystems.com), the following symbols (icons) are used for Stocks and Flows:

![Stock Symbol](image)

The SD software also uses another variable for modelling, namely, Converters. Converters are also known as ‘auxiliary variables’ which are used to hold data, constants, or mathematical or graphical relationships. The converter data or mathematics can alternatively be embedded in flow equations. However,

"The advantage of converters is that they break complex flow equations into simpler components and make the model easier to understand. In terms of understanding the way in which the system works and can be modelled, converters are very important and are significant components of the system structure." (Maani & Cavana, 2007, P.65)

The iThink software symbol (icon) for converter is:

![Converter Symbol](image)

In the next section, the process of S-F modelling is explained and an example of a Stock-Flow model is demonstrated.

2.6.1 Stock-Flow Model

A Stock-Flow model can be built from a causal loop model or directly from scratch. In general, there are more detailed variables in an S-F model than in a CLD. Hence S-F is a more powerful modelling tool than CLD as it enables the dynamic structures of a system to be captured. However, the required effort and expertise to create dynamic models is far
greater than of those for CLDs. It is also important to note that feedback loops can be more readily identified and analysed from causal loop diagrams than from stock flow models.

Figure 13 illustrates a basic structural model of CO2 accumulation in Atmosphere.

![Figure 13: CO2 in Atmosphere basic CLD Model](image)

Figure 14 shows the S-F model of the CO2 accumulation (using iThink icons). Here, the Emissions and Absorption Rates converters allow quantification of the dynamic structure embedded in this model.

![Figure 14: Stock-Flow model of CO2 in Atmosphere](image)

“Although social-ecological systems are self-organized through interactions among large numbers of biotic and abiotic variables, the most important changes can be understood by analysing a few, typically no more than five, key state variables [stocks]. This is the ‘rule of hand.’ More complex models are not necessary to explain the key...
interesting patterns and, in fact, are likely to mask them. This is both because generally humans can only understand low dimensional \([\text{stocks} < 5]\) systems and because, empirically, it appears that only a few variables are ever dominant in observed system dynamics."

2.7 Developing a simulation model

Once an S-F model is developed it can be simulated. The first step of simulation is to populate the model with data. In SD models, the data can be quantitative or qualitative and it can come from a variety of sources including scientific and statistical data bases, observations, interviews, expert knowledge, historical records, publications, survey responses, media reports, and so on. In the absence of any known data, the relationship between variables can be hypothesised and incorporated into the model in the form of "graphical functions".

After the data is entered into the model, the model can be run. This stage involves using specialised computer packages mentioned earlier. The results of these runs or experiments can be shown in sophisticated graphical or tabular forms.

2.8 Validating the model

Before a model can be used for decision making or policy analysis, the modellers and stakeholders must have sufficient confidence in the 'soundness and usefulness' of the model. However,

"There is no single test which serves to ‘validate’ a system dynamics model. Rather, confidence in a dynamic simulation model accumulates gradually as the model passes more tests and as new points of correspondence between the model and empirical reality are identified." (Forrester and Senge, 1980: 209)

Confidence in a SD model is generated through ‘validation’. Coyle (1983) offers a number of tests which could be used to validate system dynamics model. For a detailed description of simulation modelling and examples of iThink equations developed from the stock flow diagram see Maani & Cavana (2007).

2.9 Model Documentation

An important part of model building process is to produce a fully documented final report to serve as reference and ongoing learning for decision makers and their organisations. Through this many of the systems thinking and modelling skills and insights required for intervention are passed on to stakeholders and participating organisation during the process.

In particular, simulation models should be fully documented to give the source and background information for each parameter or equation. Model documentation is an important part of this process and provides a good ‘trail’ so that the decision making team or other model users are able to follow the logic and assumptions of the model.
2.10 Policy and Strategy Design

Once an SD model has been validated, it can be used for policy design and analysis. According to Maani and Cavana (2007, P.75): ¹

“In system dynamics models, policy analysis is an extremely important part of the modelling process. Usually this involves performing a carefully planned range of policy experiments with the model; varying the policy parameters or changing the policy structure of the model (i.e. by adding or deleting linkages between variables).”

“Strategies are combinations of policies intended to achieve strategic objectives. If the initial problem is a strategic issue, such as reduction of greenhouse gases to mitigate climate change, then it is likely to involve more than several domains such as economic, social and political, and solution will require co-operation across these areas. Hence it is likely that strategies (or groupings of policies) may be necessary to address the issues. A strategy development matrix can be developed to help design consistent strategies. These can then be tested with the aid of the model.” (Maani & Cavana, P.76)

¹ See Maani & Cavana (2007) for detailed examples of policy analysis in a dynamic simulation model.
http://www.pearsoned.co.nz/search-results/product-details/?isbn=9781877371035
3. SCENARIO THINKING/PLANNING TOOLS

Scenarios are a way thinking about future possibilities where no information is available or trusted. Scenario planning goes beyond forecasts and projections. While forecasts rely on historical data and trends to project a probable future, scenario planning considers alternative and plausible futures.

In relation to system dynamics, once a simulation model is constructed and validated, it can be used for planning and modelling scenarios, and testing the robustness of the designed policies and strategies to variations in scenarios.\(^2\)

There are a number of purpose-built climate change SD models that can be readily used for scenario planning. These simulation models known as micro worlds can be used by decision makers, as well as the public, to learn about climate changes dynamics and the effects of mitigation and adaptation policies on arresting the adverse consequences of climate change. (http://climateinteractive.org/simulations/bathtub) or (http://www.planetseed.com/node/15254).

IPCC (2007b) defines ‘scenario’ as

“A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships”.

Hence scenario thinking and planning are valuable tools for climate change decision making and adaptation. Scenarios can be presented in many forms, including graphs, maps, narratives, multimedia forms. In relation to climate adaptation planning and decision making, scenarios can be used to inform and improve all aspects of the process. Specifically,

“The scope of scenarios used in climate adaptation planning encompasses not only science-based climate change exposure and sensitivity scenarios, but broader social, economic and environmental factors affecting the adaptive capacity and resilience of places and population groups.” (VCCCAR, 2007)

In Australia there are a number of key sources for scenario information, listed below:

- Climate Change in Australia – Climate Change in Australia shows how Australia’s climate has changed and how it may change in the future. This website provides information on observed climate change over Australia; likely causes of climate change; and likely future changes to Australia’s climate – http://www.climatechangeinaustralia.gov.au/
- CSIRO OZClim – OzClim provides a simple step-by-step option to generate and explore climate scenarios. There are six scenarios in the examples section for rainfall and temperature for 2030. An advanced section is available for the scientific research community and policy makers – http://www.csiro.au/ozclim/home.do

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\(^2\) For a detailed example of policy/strategy development and scenario planning using SD see Maani & Cavana 2007, Chapter 5.
3.1 Learning Lab (LLab) for Decision Making

Learning Lab (LLab) is a process and technology for collaborative decision making in complex systems such as climate change adaptation, sustainability, conflict resolution, integrated planning, etc. It engages diverse stakeholders in a systemic decision-making approach. LLab takes place in a setting and environment where groups of decision makers, researchers, policy makers, community members and other stakeholders assemble to tackle shared problems. The learning Lab process integrates systems thinking skills with participatory and adaptive management. Hence, the learning lab provides a ‘safe’ space for decision making, especially where contentious issues are present and trade-off outcomes are inevitable, as is the case in climate change adaptation. As such, it helps create a shared understanding and buy-in and commitment to collective actions.

Conceptually, the learning lab follows a cyclical process (Figure 15) consisting of 3 stages: conceptualisation, experimentation and reflection as shown below.

According to Maani & Cavana (2007, p.114),

“Conceptualisation phase is where decision makers and stakeholders creatively think together to identify core issues and opportunities and to understand and challenge prevailing assumptions and boundaries.” … “Experimentation [is] where new theories and hypotheses are tested in a safe ‘laboratory’ environment. In practice, however, experimentation is rarely used in complex decision making environments where in fact decision outcomes are most crucial. This is partly due to the long implementation times as is the case of policy and regulations.”

In the Reflection stage decision makers review the process and outcomes of the experimentation and synthesise and consolidate the lessons learned. During this stage, the participants also identify new challenges or hypothesis to test in the next cycle of the Learning Lab.
The Learning Lab process allows decision makers and stakeholders to test the consequences of proposed decisions, policies and strategies. This often results in discovering inconsistencies and unintended consequences of actions and decisions before they get implemented.

3.1.1 Learning Lab Process

A key benefit of the learning lab stems from the process in which participants examine, reveal and test their mental models and those of their group or organisation. The learning lab challenge participants' mental model and tests their understanding of complexity. Research (Morecroft, 1983; Senge, 1991; Sterman 1989, Maani & Maharaj, 2004) shows that most decision makers often miss dynamics and systemic relationships in complex systems (feedback, non-linearity and delay).

Learning Lab takes place in a series of participatory workshops ranging from half-day to several days depending on the stage of the process. Through experiential learning, the participants will understand the dynamics within the complex systems – a critical skill for managers and researchers in all professions and disciplines. The blend of intellectual rigour, challenge and fun creates enthusiasm and enjoyment which are important ingredients for learning, participation and collaboration.

In summary, Learning Lab will enable the participants and their organisations to:

- Understand and effectively deal with ambiguity, uncertainty and complexity
- Foresee the unintended consequences of decisions, policies and strategies
- Identify fundamental causes and solutions to chronic problems
- Avoid misjudging problem symptoms for their causes
- Reconcile dilemma of short-term fixes vs. long terms strategies
- Bring alignment of vision and action to scientific teams and policy groups
- Apply systemic leverage for sustainable interventions

3.1.2 Learning Lab Methodology

The Learning Lab (LLab) methodology (Maani, 2011) is a generic process which can be applied to create consensus and to find systemic interventions for complex problems in a variety of domains and contexts: social, economic, environmental and cultural. The LLab comprises seven steps whereby decision makers and stakeholders including policy makers, businesses, scientists, NGOs, and the community come together to develop a shared understanding of complex issues and to create innovative and sustainable solutions. The LLab process is shown in Figure 16 below:
3.1.3 **The Learning Lab Steps**

1. **Community Workshop**
   Purpose: to identify key issues, problems and challenges (social, economic, environmental, governance, leadership) facing the industry, government or the community, e.g. climate change adaptation.

2. **Systems Thinking Training**
   Purpose: to build Systems Thinking knowledge and skills for selected representatives of decision makers in order to become directly involved in the next steps.

3. **Systems Workshop**
   Purpose:
   - to verify and validate systems map/model developed for the issues
   - to understand systemic issues and their interdependencies and the role & responsibility of each stakeholder group
   - to discuss and understand the implications for coordinated actions, strategy and policy
   - to identify key leverage areas for systemic interventions/change (based on the systems models)

4. **Systemic Planning Workshop**
   Purpose: to develop a systemic plan including priorities, funding and resources provisions. The systemic plan will integrate with and extends the existing strategic plans.

5. **Projects Planning Workshop**
   Purpose: to identify projects based on key leverage areas identified, and to design implementation plans. This step also involved engaging potential local and international sponsors and financial donors
6. Implementation
Purpose: This step is where projects, programs, are implemented. Due to inherent
uncertainty in CC it is important to view this step as a “learning experiments” whereby
relevant authorities and stakeholders participate in actions stemming from their
respective plans/strategies. As such both success and failure become sources of
learning and not a cause for blame or disappointment.

7. Reflection Meetings
Purpose: to monitor progress, identify drivers/causes of success and failure, and to
identify emerging issues and lessons learned. This step represents the core of the
learning cycle and as such it is important that Reflection Meetings are held as often as
possible (at least every 3 months).

3.1.4 Collective Decision Making and Learning
Over time, ‘new’ people could get involved in different stages of the LLab. Hence, the
Learning Lab can become an integral and ‘live’ part of collective decision making and group
learning. As decision makers and the stakeholders become engaged in repeated cycles of
the Learning Lab, the anticipated benefits and outcomes will grow and multiply. However,
not all the steps of the LLab need to be repeated in future cycles. This will steadily enhance
the “learning capacity” of those engaged in this participatory process to the point where
learning becomes institutionalised in the life of the community of practice.

In the Learning Lab process not only do the participants learn about Systems Thinking and
causal modelling skills, they also learn from each other’s expertise and experiences. This will
build trust and willingness to share experiences openly.

“In this environment the participants become more open to breaking down the
conceptual and personal barriers to collaboration and compromise. Such group
learning empowers individuals to harness their experienced-based knowledge, and
mesh it with that of people with different experiences, to produce adaptive strategies
and policies that have the potential to be more flexible and more engaging than is
usually the case” (Newell and Proust 2012, p.19).

3.2 Collaborative Conceptual Modelling (CCM)
Collaborative Conceptual Modelling (CCM) is developed by Newell and Prousta (2012) of
the Australian National University

“To help a research or policy-making group to come to terms with the feedback
dynamics of their system-of-interest. The aim of a CCM exercise is to articulate, mesh,
and extend the mental models of the members of an adaptive group, rather than
attempt to produce definitive predictions of future behaviour.”

Similar to the LLab, the CCM focuses on collaboration and adaptive management and a
‘comprehensive approach’ which blends (a) a wide range of disciplinary research, (b) in-
depth real-world experience, and (c) a broad view of the interplay between the parts of the
overall system-of-interest.
The CCM process unfolds in six activities as follow:

<table>
<thead>
<tr>
<th>ACTIVITY 1:</th>
<th>Discuss problem or situation of concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITY 2:</td>
<td>Gather historical data to reveal patterns of change over space and time</td>
</tr>
<tr>
<td>ACTIVITY 3:</td>
<td>Integrate individuals’ mental models of cause and effect</td>
</tr>
<tr>
<td>ACTIVITY 4:</td>
<td>Identify dominant stock-and-flow structures</td>
</tr>
<tr>
<td>ACTIVITY 5:</td>
<td>Identify opportunities for effective adaptation (Leverage)</td>
</tr>
<tr>
<td>ACTIVITY 6:</td>
<td>Use improved understanding of system behaviour to develop ‘memories of the future’</td>
</tr>
</tbody>
</table>

CCM uses a number of tools discussed earlier including influence diagrams, causal-loop diagrams, and stock-and-flow models in a structured framework which tries to surface and align mental models of the participants.
4. CASE STUDIES IN SYSTEMS THINKING

This section demonstrates three real Australasian case studies related to climate change and sustainability issues using Systems Thinking tools and methodologies. All three case studies have involved multiple and diverse decision makers and stakeholder. Hence, a combination of Affinity Method for brainstorming and Causal Loop Modelling has been employed. In addition, Case Study 2 illustrates use of the Four-Level Thinking Model as a precursor to causal modelling to facilitate deep collective thinking into key issues selected by the participants.

Case 1 Australian Cotton Industry and Climate Change

Case 2 Climate Change, Land Use and Water Quality – Environment Southland New Zealand

Case 3 Creating Sustainable Communities through Stakeholder Engagement – Great Sandy Biosphere (UNESCO)
4.1 Case 1 Cotton Farming System in Australia

Background

The unstable and frequent patterns of climate change induced droughts in Australia poses a major threat to its cotton industry. To this end, the Cotton Research and Development Corporation (CRDC) in its 2008–2013 Strategic Plan identified a need to develop a more holistic “systems map” of the farming system in which cotton is now grown in Australia. The aim of creating a cotton industry systems map was to help identify the critical areas where future investments in farming systems R&D could improve integration and effectiveness.

One initiative aimed at helping to achieve a cotton industry systems map was to apply the discipline of Systems Thinking to the problem. Consequently, CRDC convened a workshop in Dalby on December 10 and 11, 2008. CRDC’s aim was to use this workshop to help identify some of the potential critical areas where future strategic investment in Farming Systems R&D might be best placed. This case outlines the approach, process and outputs from the workshop. It is anticipated that some of the critical areas identified will now need to be scoped out further in order to establish the type of research or actions required to progress them.

The Challenge

A key challenge in planning and decision making is the diversity of views and stakeholders involved.

CRDC sought to involve people with a range of views and roles within both the cotton and grains industries in the workshop process. These included growers and grower representatives on GRDC and CRDC, researchers, R&D managers, marketers, extension and education officers and consultants. This acknowledges that the cotton farming system is also a grains farming system and the thinking about future investments in cotton farming systems R&D need to consider the whole system.

The Approach

The approach consisted of a two day workshop. The first part of the workshop was spent by the facilitator explaining the discipline of Systems Thinking and how it could be used to help the participants better understand and manage complexity and change. The remainder of the workshop was interactive. Participants were then split into 4 groups of 4-5 and were led by the expert facilitator through a series of steps using aspects of systems thinking and some systems thinking tools. These activities included:

- **Identifying the key drivers of the cotton farming system.** Participants individually wrote down as many of these they could think of one to a post-it note. Then in their groups post-it notes were stick to a whiteboard then grouped into themes.
- **Considering how the drivers are connected and interact.** Groups discussed how the key drivers might interact and how they were connected in a cotton farming system.
- **Each group then developed a systems map** following some instruction from Kambiz on how this was done. This concluded day 1.
- **Reviewing systems maps and major trends.** The second day commenced with a review of each group’s systems map and a short presentation on the approach and components to other groups. Each group then was asked to consider some of the
major trends influencing the cotton farming system (e.g., increasing yields, increasing costs, less labour, flat commodity prices etc.)

- **Identifying key leverage points within the systems map.** Each group was then asked to identify the key areas within their systems map where interventions would have the greatest impact.
- **Identifying the R&D that could assist with action, information of change at the points of leverage.** Time available for this activity was limited.

## Results

**Systems Maps:** The systems map developed by three groups are provided in Case 1 Figures 1-3. It can be seen that they all differ even though they all contain many elements in common. The fact that the maps differ is not unexpected, because each group had the freedom to start wherever they wanted to and draw their own conclusions on connections and interactions. Systems maps are also only a tool or a means to an end and in this case were used to identify leverage points.

**Leverage points:** The lists of leverage points from each group were combined and the descriptors grouped under common themes. These are shown in Case 1-Table 1.

**Opportunities for R&D and other investment:** The lists of potential R&D or other investment that could address the key leverage points from each group were combined and grouped under common themes. These are shown in Case1-Table 2.

## Conclusion

Prior to concluding, the participants discussed what they had gained from the workshop personally. In many cases it was the way in which systems thinking enabled new perspectives to be gained and how the “system” could look different depending on the starting point and the interactions that this generated. A number of participants observed that many of the leverage points identified described aspects related to developing people’s skills and capacity to improve their management rather than direct improvements in the management of the crop system itself. This was not something that they had anticipated at the start. The overwhelming view was that participants had found the approach and systems tools were effective and worthwhile.

The group also discussed what had been achieved and where to go next. It was concluded that it would be worthwhile putting some further effort into discussing and developing the leverage points identified as it was felt that this provides a strong base for the ideas and opportunities for investment in R&D to be effectively developed.

The Systems Thinking approach provided a powerful contrast to the commonplace strategic planning tools that focus on different issues in isolation and are developed without the active participation and engagement of divers stakeholders.
Case 1 Figure 1: Systems Map – Group 1
Case 1 Figure 2: Systems Map – Group 2

Decision-making for climate change adaptation: a systems thinking approach 42
Case 1 Table 1: Key Leverage or Intervention Points emerging from Systems Maps

<table>
<thead>
<tr>
<th>Category</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- &quot;Eco-label&quot;</td>
</tr>
<tr>
<td>Business Management</td>
<td>Business Health</td>
<td>Management skills</td>
<td>Business structure and strategy</td>
<td>Human Capacity (Leadership)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- grower skills &amp; knowledge</td>
<td></td>
</tr>
<tr>
<td>Staff</td>
<td>Staff</td>
<td>Training &amp; up-skilling</td>
<td>Public perception -labour attraction</td>
<td>Tell our story effectively (public perception)</td>
</tr>
<tr>
<td>Farming Systems</td>
<td>Systems R&amp;D for newer systems</td>
<td>Research priorities</td>
<td>Input-Replacement Technology</td>
<td>Farming Systems that are matched to climate variability (Focussed, relevant R&amp;D)</td>
</tr>
<tr>
<td>BMP development and adoption</td>
<td>Where does sociology fit?</td>
<td>QA &amp; BMP and Extension process</td>
<td>Government recognition and perception</td>
<td>Adoption of BMP (Sustainable practices, stewardship)</td>
</tr>
<tr>
<td>Public perception</td>
<td>Is the balance right?</td>
<td></td>
<td>International Year of Natural Fibre 2009</td>
<td>Tell our story effectively (public perception)</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>Science Capacity</td>
<td></td>
<td>Consolidation of Industry Bodies (Effective industry leadership)</td>
</tr>
</tbody>
</table>
### Case 1 Table 2: Research ideas generated from leverage/intervention points from Systems maps

<table>
<thead>
<tr>
<th>Category</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Value/Demand</td>
<td><strong>Via quality (objectively measured)</strong></td>
<td><strong>Premium cotton and QA in the processing chain</strong></td>
<td><strong>New Technologies</strong></td>
<td><strong>Improving demand:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Eco branding</strong></td>
<td><strong>-GM traits</strong></td>
<td><strong>- Spinning trials</strong></td>
</tr>
<tr>
<td>Systems R&amp;D</td>
<td><strong>Farmer and science support, generalise</strong></td>
<td><strong>Research model</strong></td>
<td><strong>System responses to management challenges &amp; changes</strong></td>
<td><strong>Farming systems matched to climate variability:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Plus economic (scientist skills) partnerships (spread applicability)</strong></td>
<td><strong>Cross commodity research</strong></td>
<td></td>
<td><strong>- Case Studies</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Irrigated agriculture focus</strong></td>
<td></td>
<td><strong>- Quantify outcomes of leading practice</strong></td>
</tr>
<tr>
<td>Staff, skills, training</td>
<td>*** staff skill &amp; management**</td>
<td><strong>Delivery of education &amp; learning</strong></td>
<td><strong>New Technologies</strong></td>
<td><strong>Quantify Outcomes of Leading Practice e.g.:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>skills, delegation, training time, availability, autonomy</strong></td>
<td></td>
<td></td>
<td><strong>- Case Studies</strong></td>
</tr>
<tr>
<td></td>
<td><strong>pool to select, cultural background, higher skills with time, lifestyle</strong></td>
<td></td>
<td></td>
<td><strong>- Extend Farrar High Model</strong></td>
</tr>
<tr>
<td></td>
<td><strong>business, operational skills, time management, people management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>training blocks etc increase $ in capacity building</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| BMP          | BMP - delivery of research  
Ensure content in program is best practiced. | Document and communicate TBL benefits of BMP adoption |
|--------------|------------------------------------------|------------------------------------------------------|
| Business Health | * Operations/technical decision making  
* Finance/marketing/business skills (balance of effort)  
* staff skill & management |                                                      |
| Other        | * decision making, demographics         |                                                      |
4.2 Case 2 Climate Change, Land Use and Water Quality

Background

Climate change with its effect on water quantity and quality is an issue of growing significance to sustainable agriculture. There have been numerous calls internationally to take action to address the problem (Mattikalli and Richards, 1996; Tong and Chen 2002; Foley, JA, et al 2005).

This case study outlines the Environment Southland (NZ) project to review existing regional plans that relate to discharges to land and to bring them into alignment with the objectives and policies set out in their operative Regional Water Plan. There have been growing pressures from the community requiring policies to mitigate the effects of land use on water quality, whilst ensuring any recommendations were based on sound science and developed in collaboration with the community.

The Challenge

Over the past 20 years, there has been considerable improvement in the management of point source discharges to land and water in New Zealand. Consequently, the quality of many streams and groundwater historically affected by point source discharges has greatly improved through better regulation, monitoring and industry initiatives. The current challenge is how to manage the impacts of diffusion of nutrients from a range of land use activities and intensities on water quality.

The primary focus of the land use and water quality (LUWQ) project is to address the effects of non-point source or diffuse pollution arising from land use activities related to farming across the region. The initial aim of the project was to develop a policy framework that would allow the region to achieve the policies and objectives outlined in the Regional Water Plan. A key success factor will be strong and co-ordinated links with all stakeholders involved with the project. This aim will be achieved via two key work streams:

1. Developing a policy framework for Focus Activities, which are considered to have potential to affect water quality. These activities are nutrient management, riparian management, intensive winter grazing, and hill country development and land use intensification. Current work to introduce a rule in relation to new dairy conversions is being advanced as part of land use intensification.

2. Implementing a regional response, to allow meeting obligations through the development of water quality and quantity limits and targets. Council is then required to work with the community and stakeholders to determine methods of allocation to meet those targets.

The Approach

The project team decided to adopt a systems approach to address the issue of water quality management in Southland. The systems approach was selected as it creates shared understanding of complexity and associated uncertainties. It also provides a way of identifying leverage points for change, potential obstacles or barriers and latent unintended consequences of decisions and actions.

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4 Adapted from Wedderburn, L & Maani K., Systems Thinking for Transformative Agriculture - Case of Land Use and Water Quality in NZ Southland, AgResearch, New Zealand, 2012

liz.wedderburn@agresearch.co.nz
A workshop was held in December 2011 in order to introduce the LUWQ project to a range of stakeholders. The workshop allowed Councillors and stakeholders to explore in depth the issue of land use and water quality and the relationships with community well-beings (economic, social, environmental and cultural). Through this a whole-of-system understanding was established which set the context for the future progress of the LUWQ project.

The outcomes expected from the Council-arranged workshop were to be a clear understanding by Environment Southland councillors and invited sector groups of:

1. The linkages and interdependencies between water quality/quantity, land use, economics, social and cultural outcomes, and
2. The identification of the areas that the LUWQ project could potentially influence, and therefore, the factors that needed to be taken into consideration as the project progresses.

Workshop participants consisted of Environment Southland councillors, council staff and invited stakeholders representing various sectors. Altogether over 30 participants attended the workshop.

The exercises that the workshop participants undertook were based on Systems Thinking group decision-making methodology (Maani & Cavana 2007, Ch.7). Two exercises were conducted with the participants divided into six mixed groups.

Exercise 1 used the Four Levels of Thinking Model to enable the participants to view issues in greater depth and in a systemic manner and to gain greater insights into structures, processes and behaviours that influence observed events/outcomes. The results of this exercise are discussed in the following section.

Exercise 2 focused on addressing the question: “What are the factors and relationships that link land, water and people in the Southland Region?” Here, all groups first generated the factors (variables, drivers, barriers) and then looked at the relationships amongst them. This information was then used by AgResearch facilitators to develop Causal Loop diagrams (CLDs) for identified factors. This exercise will be discussed in detail in subsequent sections.

Workshop participants were first introduced to the Four Levels of Thinking model for exploring the land use and water quality issue in a systemic way. This allowed them to broaden their outlook and prevented quick-fix and ‘jumping-to-conclusion’ tendencies. Then, the participants explored the LUWQ project by systematically going through the four levels of thinking.

The participants were asked to first choose within their group an event related to land use and water quality. As discussed earlier, event is defined as an incident or experience that has occurred in the past with material outcome on the participants. This thinking triggers the mind of the participants and anchors their thinking in a real and tangible experience, as opposed to abstract thinking, complaining, or navel-gazing.

Generally, events can be gleaned from a variety of sources, including the media. In relation to land use and water quality, for example, some headlines read “NZ faces time bomb on water quality”; “Declining water quality”, “Concern over poor water quality at lake” (www.stuff.co.nz). This information on events generally reports on what, when, how which only touches the surface of the issue and often leads decision makers to offer immediate solutions (quick fixes). As stated earlier, analysis of patterns and trends associated with the event will allow a richer picture to emerge. However, often patterns are viewed in isolation and little consideration is given to
how they interact and affect each other. Understanding this interaction allow decision makers to think even deeper and reveals underlying systemic structures that influences observed patterns and events. As discussed earlier, in order to transform the problems and identify systemic solutions, decision makers must understand the mental models that people hold which underpin the reasons they do things. Change at this level is a powerful means for transformation. However, because mental models are personal values and deep feelings they are not generally discussed openly neither they come to surface in group interactions (Maani & Cavana 2007).

Below are responses to the four-level thinking in relation to the event identified (major flooding) by one of workshop groups. The responses are verbatim generated from individual participant’s ‘silent’ brainstorming collated within each group.

**Case 2 Table 1: Four Level of Thinking Responses (Group 2)**

<table>
<thead>
<tr>
<th>EVENT</th>
<th>Major Floods</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATTERNS</td>
<td>• Larger floods</td>
</tr>
<tr>
<td></td>
<td>• Change in weather patterns/Climate change</td>
</tr>
<tr>
<td></td>
<td>• Increased infrastructure and development in flood plains</td>
</tr>
<tr>
<td></td>
<td>• River straightening/clearance (vegetation)</td>
</tr>
<tr>
<td></td>
<td>• Bed aggradations</td>
</tr>
<tr>
<td></td>
<td>• Loss of knowledge</td>
</tr>
<tr>
<td></td>
<td>• Wetland drainage</td>
</tr>
<tr>
<td></td>
<td>• Higher intensity rainfall</td>
</tr>
<tr>
<td>SYSTEMIC STRUCTURES (Policies/processes/behaviours)</td>
<td>• Reliance on “advisors”</td>
</tr>
<tr>
<td></td>
<td>• Institutional inertia/slowness to respond</td>
</tr>
<tr>
<td></td>
<td>• Restrictive rules discourage intervention</td>
</tr>
<tr>
<td></td>
<td>• Permissive rules allow adverse effects</td>
</tr>
<tr>
<td></td>
<td>• Different groups have different interests, agendas</td>
</tr>
<tr>
<td></td>
<td>• Spending priorities of agencies/bodies</td>
</tr>
<tr>
<td></td>
<td>• Economics of different land uses</td>
</tr>
<tr>
<td></td>
<td>• People are assumed to take responsibility/inform themselves</td>
</tr>
<tr>
<td>MENTAL MODELS (Attitudes/world views/assumptions)</td>
<td>• I don’t believe it</td>
</tr>
<tr>
<td></td>
<td>• It’s nothing to worry about</td>
</tr>
<tr>
<td></td>
<td>• No one told me</td>
</tr>
<tr>
<td></td>
<td>• Someone should have stopped me</td>
</tr>
<tr>
<td></td>
<td>• I can’t do anything about it</td>
</tr>
<tr>
<td></td>
<td>• Someone else should pay</td>
</tr>
<tr>
<td></td>
<td>• Not my problem/job</td>
</tr>
<tr>
<td></td>
<td>• Profit maximisation</td>
</tr>
<tr>
<td></td>
<td>• Pandering to the squeaky wheel(s)</td>
</tr>
<tr>
<td></td>
<td>• It won’t happen again in my lifetime</td>
</tr>
<tr>
<td>EVENT</td>
<td>Major Floods</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>•</td>
<td>Zero rate increases</td>
</tr>
<tr>
<td>•</td>
<td>Why didn’t you listen to me?</td>
</tr>
<tr>
<td>•</td>
<td>It’s my land so piss off!</td>
</tr>
</tbody>
</table>

As can be seen from the responses, systemic structures underlie relationships and interconnections, while mental models reveal entrenched feelings, views and assumptions. Understanding these levels is critical to creating shared understanding of issues and commitment to group decisions and harmonious action.

**Results**

The second part of the workshop involved creating causal models for key factors linking land use and water quality. This exercise focussed on addressing the question:

"What are the factors and relationships that link land, water and people in the Southland Region?"

The purpose of this exercise was to take the discussion deeper to explore the underlying drivers and dynamics that cause the issues of concern to the Council and stakeholders. Again, each group addressed this question by first generating individual factors and then linking them into a "systems map" using causal loop modelling.

As discussed earlier, a causal loop model (CLD) tells a unique narrative of causal relationships. This narrative is underpinned by assumptions that need to be verified by the group. It illustrates the importance of the context and interdependencies as well as the requirement for precise language that come to surface in the development of the models. Thus, the narratives make transparent the mental models of the participants.

In total six CLD models were developed by the groups. Below two of these models (Groups 1 and 2) are shown and discussed. A third CLD which combines the key factors of all groups is also presented and interpreted. The combined CLD indicates the collective thinking and mental models of the entire workshop groups in relation to land use and water quality.

**Narrative Group 1**

Group 1 explored climate change and flooding events and their consequences on soil and water quality. Their CLD is shown below.
Case 2 Figure 1: Group 1 CLD for effects of climate change on land and water quality

The above CLD demonstrates the group’s view on how the flooding-erosion reinforcing dynamic impacts on both soil and water quality which in turn will impact on farm activities and effectiveness. The increase in the use of irrigation is encouraged by water quantity which has reciprocal impacts on river level and further flooding. As discussed earlier, the reinforcing loops (R) can fortify either positive (virtuous) or negative (vicious) impacts. Understanding reinforcing loops helps identify where an intervention can be placed that will amplify the positive behaviour and minimise the negative. For example, an intervention that will reduce erosion will also reduce flooding and improve water quality and decrease the loss of soil on the farm. The balancing loop (B) associated with irrigation and water quantity (i.e. the more water taken, the less water remains for taking) will assist in countering the irrigation-farming reinforcing loop, where more farming increases the need for irrigation and vice-versa; and more irrigation enhances farming.

Narrative Group 2

This CLD shows the impacts of regulations on land use and water quality. An unintended consequence of regulations that had encouraged riparian planting to improve water quality has been the inability of people to access their recreational grounds and hence affecting their “pride and enjoyment”. This, in turn, had raised concerns over the long term consequences of regulations on economic prosperity of the region.
Further, there were fears that the intended interventions would not go far enough and that water quality will not improve in the foreseeable future. The above CLD illustrates this through a lag symbol (delay) between land use and management and water quality.

Key interventions that were identified by this group were adoption of land plan; education; telling of success stories; changing attitudes; and that the rules should not be too prescriptive. The key (leverage) is developing regulations that facilitate “appropriate” land use and management.

Narrative Group 3

This group focused on the importance of food production and the link between the emotions associated with change as well as the integration of economic and social prosperity with that of environmental stewardship. This led the group to conclude that interventions targeting emotions around change as well as considerations for food production will create reinforcing patterns that will reverberate throughout the system. Testing how the LUWQ project will enable these reinforcing loops will assist in identifying any unintended consequences.

Narrative Group 4

Group 4 introduced the concept of Mauri (a Maori term for life force that took into account food for future survival and generations). In their CLD, the group connected attitudes and behaviours and the influence of societal expectations to legislation, economy and natural resource state. This suggests interventions targeted at
harmonising attitudes and beliefs as well as knowledge to assist land use change will have major impacts on the whole system.

**Narrative Group 5**

This group CLD had similar drivers as those in groups 3 and 4. However, this group introduced the impact of compliance costs on land use and management and its flow-on effect on food provision and demand.

**Narrative Group 6**

This group CLD captures similar concepts and relationships to that of groups 3, 4, and 5. The added factor here was the increase in migration to the region because of the shift to dairy systems.

Despite the fact that each of the six workshop groups identified different sets of factors and drivers in relation to land use and water quality, there are remarkable similarities between the systems models generated by all groups. In particular, the recognition of interdependencies between the economic, natural and societal/cultural wellbeing as well as the influence and importance of attitudes and behaviour on decision outcomes are noteworthy. These insights served as critical input for the design of policies for the LUWQ project as sustainable interventions will have to take into account the whole of the system and not just parts of it.

**The Overall Model**

Figure 3 below shows an overall CLD model developed from the integration of the six group CLDs. As can be seen, most of the loops are of reinforcing (R) nature which push the system in either upward or downward directions, depending on the current conditions of the system. That is, if the system is in a positive and favourable state, these dynamics will further improve systems behaviour and outcomes. If, on the other hand, the system is in a poor state its condition will grow worse over time.

There are three balancing loops in the model as well that serve to moderate, counteract or reverse the direction of change. Balancing loops B1 & B2 show the effects of government regulations on compliance cost as well as on the attitudes and behaviours of stakeholders, leading to lower economic and employment activities. The “Balanced Wellbeing” variable in the B2 loop indicates the value and importance, to decision makers and stakeholders, of a holistic and integrated social/cultural, economic and environmental approach.

The third balancing loop (B3) shows the reciprocal effects between irrigation activities and water quantity and quality. That is, more water encourages more irrigation but more irrigation reduces water quantity and quality, limiting further irrigation. This become a self-regulating mechanism for irrigation management and control.

Also noteworthy in the model is the prominence of intangible variables and their influence on overall model behaviour. These include emotions and values, cultural and spiritual wellbeing, stewardship and attitudes and behaviours. The presence and primacy of such ‘soft’ variables are often overlooked in group decision making and expert driven modelling, making decisions divorced from human psyche and often doomed to fail.
Insights Gained

Following the above exercises the groups were asked what insights they had gained from the land and water quality systems approach and which insights would be critical to have as part of the Land and Water Quality project. As a result the following have been identified as critical success factors by the participants:
### Case 2 Table 2: Critical Success Factors for the Land Use and Water Quality project

| Community engagement                                                                 | • Community involvement and support (ownership)  
|                                                                                     | • Community buy-in and acceptance of a need to change  
|                                                                                     | • Community must be part of process  
|                                                                                     | • Community engagement and involvement  
|                                                                                     | • Community trust, communication and relationship  
|                                                                                     | • Diverse stakeholder representation and ownership  
| Behaviour Change                                                                     | • Attitudinal change  
| Balanced Outcomes                                                                   | • Recognise economic, social and environment aspects when setting the desired outcome  
|                                                                                     | • Integrated management of resources  
|                                                                                     | • Vibrant sustainability people/ land and water  
|                                                                                     | • Four well-beings not being compromised  
| Credible science                                                                     | • Science to back up  
|                                                                                     | • Independence and accuracy  
| Goals, targets, purpose                                                               | • Clear concise outcomes (understood and achievable)  
|                                                                                     | • Goals and targets  
|                                                                                     | • Shared common purpose agreed. Clear objectives and measurable outcomes  
|                                                                                     | • Agreed framework to drive change  

It is interesting to note that the great majority of these ‘success’ factors are of social and behavioural nature highlighting the need for greater trust, cohesion, engagement and shared vision.

**Conclusion**

The case study demonstrated that for an acceptable and sustainable outcome, the LUWQ project will have to address a *system* that connects people, resources and the four well beings: social, economic, environmental, and cultural/spiritual. This conclusion is in sharp contrast to commonplace ‘point solutions’ where different issues are addressed by experts in isolation. The workshop process has identified a number of critical success factors that need to be taken into consideration in the development of policy design. The systems models (CLD) developed as part of this case study can be used as a framework to verify the assumptions, patterns, structures and relationships underpinning the existing system and its behaviour.

The group exercises engendered a systemic and shared understanding of the system by all stakeholders which will facilitate identification of leverage points for change and interventions for the LUWQ project. Further, this will allow for the testing and reality-checking of the consequences of these interventions before they are implemented.
4.3 Case 3 Learning Lab for Sustainability (UNESCO Biosphere Reserves)

Background
Biosphere as Learning Lab

Since 2008, the Learning Lab has been applied as a core methodology in selected UNESCO Biospheres in Australia, Viet Nam (Nguyen 2010), Cambodia and China as pilot projects for other Biospheres globally.

Learning Lab methodology has also been used in several sustainability and public policy projects in Australia (Clean Energy policy, Cotton industry strategy, environmental protection regulations, etc.) and New Zealand (biosecurity and border control, animal welfare policy, water quality, plant genetic modification, rural futures, etc.).


“Biosphere reserve could be a context-specific experiment in sustainable development at varying scales…The emphasis on biosphere reserves as learning laboratories for sustainable development provides interesting opportunities to track such changes in site-specific application of the principle and practices of sustainable development. A prudent way forward would be to encourage use of research, data gathering and monitoring of change so that it becomes a routine practice for testing the validity of assumptions made with regard to the relationships between conservation and the sustainable use of biodiversity as well as the socio-economic development.

What is envisaged are biosphere laboratories full of on-going experimentation used by national authorities and international policy constituencies to generate insights and hopefully occasional successes for integrating specific conservation and development agendas. Demonstrating the role that learning and knowledge accumulation plays in integration could perhaps be the best contribution of MAB and its biosphere reserves to sustainable development practices over the next 5–10 years. It is UNESCO MAB firm belief that the next phase of the evolution of the biosphere reserve concept and practice must emphasise such a learning approach. Due to the dynamic nature of this approach, knowledge generated from relevant scientific research and monitoring and on-ground experience has an important role to play in informing management actions and policy decisions in response to uncertainty and continuous change.”

The ‘learning cycle’ approach has also been advocated by other researchers. For example, Edmunds and Wollenberg (2001) in relation to forest policy in Asia observe:

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5 Biosphere is designation of UNESCO Man and Biosphere (MAB) Program. UNESCO has currently 562 Biosphere sites in 109 countries around the world

Decision-making for climate change adaptation: a systems thinking approach 56
“The only reasonable approach to policy making has been and is increasingly to accept the uncertainty and complexity and put into place mechanisms for monitoring, analysing and adapting policies in a timely and efficient manner.”

The Challenge
Climate change and sustainability are complex, multi-level and multi-actor phenomenon embodying characteristics of complex adaptive systems (i.e., emergence, bifurcation, and self-organisation) as well as system dynamics (delay, feed-back loops, nonlinearity). These phenomena cannot be approached and solved by conventional reductionist and expert driven methods. This case study will demonstrate the application of Learning Lab in Great Sandy (a UNESCO designate Biosphere) in Australia.

The Learning Lab engages diverse stakeholders in a scientific and unifying process of decision making, planning and cross-agency collaboration leading to shared purpose and aligned goals and actions. The learning Lab process incorporates systems thinking and complex decision making skills in a participatory and learning environment.

The Approach
A significant benefit of the learning lab stems from the process in which participants examine, reveal and test their mental models and those of their organisation. The learning lab challenge participants’ mental model and their understanding of complexity. Research (Morecroft, 1983; Senge, 1991; Sterman 1989, Maani & Maharaj, 2004) shows that most decision makers often overlook dynamics and systemic relationships in complex systems (feedback, non-linearity and delay).

In practice, Learning Lab takes place in a series of participatory workshops ranging from half to several days depending on the stage of the process. Learning Lab workshops enable the participants and their organisations to:

- Understand and effectively deal with ambiguity, uncertainty and complexity
- Foresee the unintended consequences of decisions, policies and strategies
- Reconcile short-term vs. long terms interventions
- Avoid misjudging problem symptoms for their causes
- Bring alignment of vision and action to scientific teams and policy groups
- Apply systemic leverage for sustainable interventions

Great Sandy Biosphere, Australia
The Great Sandy Biosphere (GSB) was established in 2008 under UNESCO Man and Biosphere (MAB) Program. Biospheres are selected based on their unique natural (biodiversity), cultural, and social significance. The purpose of UNESCO Biosphere designations is to create environments where man and nature could coexist in a harmonious balance. As such biospheres have the potential to become microcosms for climate change adaptation, sustainability and societal change.

Great Sandy (Fraser Coast) is one of the fastest growing regions in Queensland, Australia, with a current population of around 100,000. The largest town is Hervey Bay (50,000), followed by Maryborough (23,000), one of the oldest settlement towns in Australia. Great Sandy also includes a series of small coastal towns with populations of around 1000 each.
In 2010 GSB initiated the establishment of Learning Lab in its region. In total, five workshops were held with an average of 28 people in each workshop representing a wide spectrum of the community, business and industry, local and state government, and indigenous and scientific groups (see Case 3-Appendix 1 for details). Due to the large geographical spread of GSB, the workshops were repeated in Gympie and Maryborough. The workshops were made possible by a partnership between the Biosphere management group (BMRG), the councils, the community and the industry.

Results

The workshops generated a large volume of ‘raw’ data arising from issues of local interest and concern. Following each workshop the data were tabulated and developed into a number of systems models (Causal Loop Diagrams) where the interconnections and dynamics among these issues were captured. A sample of a systems model generated from the Gympie workshop is shown below. The model shows key variables (issues, drivers, barriers) and their interrelationships. More causal models are appended at the end of this case.

Case 3 Figure 1 A sample subsystem model from a community workshop

Following the initial workshops, follow-up workshops were held in each locality. The purpose of these workshops was to review the systems model, discuss key drivers of change and identify key leverage points. Leverage points provide focus for united stakeholder actions, resource/ funding allocation, investment decisions and interventions for a sustainable future. The following is the list of key leverage points identified and discussed by the participants (numbers in brackets indicate number of groups that identified that leverage point):

1. education and awareness of biospheres and its potential benefits (6)
2. community consultation/involvement with industry groups (4)
Subsequent to the follow-up workshops, project workshops were held to reach agreement on priorities and commitment for actions and to generate activities and projects stemming from the leverage points. Here, using the above leverage points, cross-sector groups selected a series of projects for implementation (step 5 of the LLab).

**Conclusion**

Subsequent workshops will focus on implementation and reflection parts of the Learning Lab, where project groups will review and share their success (or lack of it), challenges and learning with other project groups, and look for further areas of improvement and innovation.

All workshops were open to all stakeholders and community members. In particular the industry groups, local councils and state and federal government agencies and NGOs participated. It must be emphasized that the purpose of these workshops was not to duplicate or create alternative action plans to those of local, regional and federal agencies. Rather, leverage points often point to more fundamental and yet overlooked *soft* issues such as mutual trust, historical baggage, and entrenched mental models (culture, ethnicity, social class, etc.) that underpin stakeholders' relationships, collaboration and the ultimate success of interventions. In the LLab sessions, the *soft* issues come to surface in a ‘safe’ and respectful environment. As a result shared vision and commitment for united actions will ensue leading to favourable long term outcomes.

Currently, other UNESCO Learning Labs are underway in Viet Nam (Nguyen, 2011) Cambodia and China using similar processes. Despite national, political and cultural differences between these biospheres, the Learning Lab concept and process have been received with equal openness and enthusiasm in these sites, as an innovative and engaging process for decision making, planning, and consensus building for complex multi-dimensional, multi-stake holder sustainability challenges. The followings are sample testimonials:

**LLab Testimonials**

“A *systems approach is an elegant way to address multiple dimensions of sustainable development planning and practice in biosphere reserves. The learning laboratory initiative in Cat Ba (Vietnam) isolated capacity for integrated planning as the major “missing link” to meet the multiple use objectives of that biosphere reserve and have given better focus to planning follow-up projects*”.

Dr. Ishwaran Natajaran, Director of the Division of Ecological and Earth Sciences, General Secretary of the Man and the Biosphere Programme (UNESCO Paris)

“For environmentally sustainable and responsible tourism development in the context of Cambodia - the systems thinking approach is a magnificently responsive and
excellent tool. This approach can be applied in various fields and sectors scientifically, logically and practically.”

H.E. Dr. THONG Khon, Minister of Tourism (Cambodia)

“The learning laboratory being built in Nen River Basin, Northern East of China is of great importance to the sustainable utilisation of water resources, environmental protection, as well as improving the livelihood of people in this region”

Dr. Hong Wang, Deputy Director of Songliao Bureau of Water Resources Protection, Songliao Commission of Water Resources, Ministry of Water Resources (PR China)

“The learning laboratory for sustainability initiative and its systems thinking approach are of significant importance for the sustainable development of Cat Ba Biosphere Reserve, Hai Phong City, Vietnam”

Dr. Nguyen Van Thanh, Mayor and Chairman of the People’s Committee of Hai Phong City and Chairman of Hai Phong City’s Sustainable Development Council (Vietnam)
Case 3 – Appendix

Summary of GSB LLab Workshop Participants Groups

Community workshop Gympie (No.1) 27 September 2010
31 attendees in total: Business/industry 4, State government 2, Council 4, Conservation 5, natural resource management 6, community group 2, individuals 2, indigenous 4, education 2.

Systems workshop Gympie (No. 2) 25 October 2010
24 attendees in total: Business/industry 2, State government 2, Council 1, Conservation 4, natural resource management 3, individuals 6, indigenous 4, education 2.

Community workshop Maryborough (No. 1) 26 October 2010
27 attendees in total: Business/industry 6, State government 2, Council 5, Conservation 5, natural resource management 2, individuals 7.

Project workshop Maryborough (No. 2) 10 February 2011

Project Workshop Gympie (No. 3) 28 March 2011

The following pages show sample Causal Loop Diagrams, generated at the workshop, representing barriers/drivers for an ‘ideal future’ for GSB in relation to Community and Industry and Governance and Coordination, respectively.
Drivers and Barriers to Your Ideal Future for GSB
COMMUNITY & INDUSTRY

- Industry group engagement
- Strings attached to corporate funding
- Mutual respect for different community sectors
- Improved decision making

COMMUNITY

- Community Cohesion
  - Unity
  - Consensus
  - Mutual respect for different community sectors

- Community Consultation/Involvement
  - Indigenous/cultural value awareness
  - Separate/conflicting objectives/agendas

- Dialogue between stakeholders
  - Fear of win-lose outcomes
  - LLab a key driving force

- Community empowerment
  - Knowledge about BR benefits
  - Community confusion over how WH, state protected areas and BR integrate and coexist

- Communication between Gov't dept & Community
  - Understanding of the scale + intricacies of GSB

- Community consultation/involvement
  - Vested interests w/investment in status quo

- Dialogue between stakeholders
  - Separate/conflicting objectives/agendas

- Cooperation between stakeholders
  - Competing priorities (environ vs. econ)

- Planning priorities
  - Perception that BR is about “locking up land” + restrictive to business
  - Perception that sustainable practices will be too costly + unproductive

EDUCATION

- Quality of the Environment + Lifestyle

- Funding support
  - Lack of awareness of sustainability issues

- Industry understanding of BR benefits
  - Lack of awareness of BR + its potential

- Knowledge about BR benefits
  - Perception of BR as another level of bureaucracy

- Perception that sustainable practices will be too costly + unproductive
  - Perceived high cost of sustainable practices + unproductive

- Motivation/willingness to engage
  - Recongnition of the community

- Community cohesion
  - Separate/conflicting objectives/agendas

- Community empowerment + ownership
  - Knowledge about BR benefits

- Community consultation/involvement
  - Vested interests w/investment in status quo

- Dialogue between stakeholders
  - Fear of win-lose outcomes

- LLab a key driving force

Vested interests w/investment in status quo

Industry understanding of BR benefits

Knowledge about BR benefits

Communication between Gov't dept & Community
Drivers and Barriers to Your Ideal Future for GSB
GOVERNANCE & COORDINATION

- Lack of political vision/will
- Lack of tangible + timely outcomes
- Policy outcomes not measured
- Disjointed mgmt (region-state-fed)
- Multiple Gov't Depts
- Governance & Coordination
- Compartmentalisation of processes
- Legal barriers EPBCACT, State & Local Acts
- Enforcement of rules and laws
- Lack of local governance transparency + accountability
- Red tape/bureaucratic control
- Short term insecurity of funding commitment
- Policies not funded/implemented
- Lack of Gov't support
- Short term election cycles
- LLab as a key driving force
- Poor legislation

Kambiz Maani
20/10/10
OTHER SYSTEMS THINKING RESOURCES

System Dynamics Society is an international, non-profit organization devoted to encouraging the development and use of Systems Thinking and System Dynamics around the world – http://www.systemdynamics.org/

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