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Managing Complex Issues through Evolutionary Learning Laboratories

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Review

Managing Complex Issues through Evolutionary Learning Laboratories#

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Abstract

Policy makers, managers and leaders in organizations, governments and business institutions are under increasing pressure to make the right management decisions in the face of a continually changing political and socio-economic landscape. To make matters more challenging the complex environmental, socio-economic, business-financial issues that decision makers need to deal with tend to transcend the jurisdictions and capacities of any single organization.

There is a multitude of difficult, long-term global challenges ahead, almost all of which are coupled with the most pressing concerns of different countries at national and local levels. Despite many efforts to deal with these complex issues facing our society the solutions so far have seldom been long lasting, because ‘treating the symptoms’ and ‘quick fixes’, using traditional linear thinking, are the easiest way out, but do not deliver the solutions.

This paper describes the processes for unraveling complexity through participatory systems analysis and the interpretation of systems structures to identify leverage points for systemic interventions. It further demonstrates the promotion of effective change and the enhancement of cross-sectoral communication and collaborative learning. This learning focuses on finding solutions to complex issues by applying an iterative, systems based approach, both locally – Evolutionary Learning Laboratory (ELLab) – and globally – Global Evolutionary Learning Laboratory (GELL).

A generic framework and processes for implementing and institutionalising ELLabs are described, and how these become part of the GELL for managing complex issues are explained. Four case studies are used to demonstrate diverse examples of the application and implementation of the ELLab approach.

Keywords: management; policy making; investment decisions; complexity; systems thinking; participatory systems analysis; Global Evolutionary Learning Laboratory (GELL).

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INTRODUCTION

Complexity characterises the world and all human endeavours today – in business, government, social, natural, scientific and political spheres. Local and global problems and challenges facing our world today are highly complex in nature, involving decision makers, scientists, NGOs and various other stakeholders. These problems and challenges cannot be addressed and solved in isolation and with the single dimensional mindsets and tools of the past. Collaborative, systemic, and integrated approaches are essential to deliver the sustainable outcomes desired. It has become crucially important for decision makers and managers involved in the management of any system to be equipped with the necessary capabilities and skills to make good policy and management decisions.

In recent years there has been a growing recognition of human capacity development as a key lever for sustainable economic, social, and ecological development. However, recent literature on the success of external actors and agencies in implementing effective change in developing countries or regions shows poor outcomes across the board (Umaña 2002; Land, Hauck et al. 2009; Thomas and Amadei 2010). One of the key barriers to progress is the lack of common understanding and shared vision of how to address the complex issues facing our world. The lack of cross functional collaboration leads to fragmented decision-making and uncoordinated actions. This is further exacerbated by cross purpose negotiations, the wasting of public and natural resources and a loss of confidence in leadership and governance. Over time these all escalate into a vicious cycle of mediocre performance and poor outcomes for all concerned. A further important contributor to poor outcomes is the fact that many of the ways in which problems are being addressed are simply ‘quick fixes’ or ‘treating the symptoms’. The establishment of a systems based Learning Laboratory (LLab) has proven to be an innovative and effective approach (Bosch and Nguyen 2011; Nguyen, Bosch et al. 2011) for dealing with highly complex and multidimensional problems and ensuring that solutions will be found at the level of the root causes.

In addition, we manage the systems we are part of in a highly compartmentalised structure – organisations, divisions within organisations, business institutions, government departments, university schools, disciplines, etc. These structures help our society to operate in an orderly way. However, without an understanding that all these different sectors in life are highly interconnected and that there is a strong need for interdisciplinary, cross-sectoral communication and collaboration, solutions that effectively address the multi-dimensional and multidisciplinary nature of complexity will remain elusive.

This paper presents the methodology and application of a ‘new way of thinking’ and radical approach to enhancing cross sectoral and organizational communication and collaboration, to deal with increasing complexity and to promote effective change at local and global levels.

SYSTEMS THINKING

Although systems thinking is an ‘old’ concept (Midgley 2003) it is increasingly being regarded as a ‘*new way of thinking*’ to understand and manage complex problems at both local or global levels (Bosch, King et al. 2007; Cabrera, Colosi et al. 2008). Maani and

Cavana (2007) use the analogy of an iceberg to illustrate the conceptual model known as the Four Levels of Thinking (Figure 1) as a framework for systemic interventions.

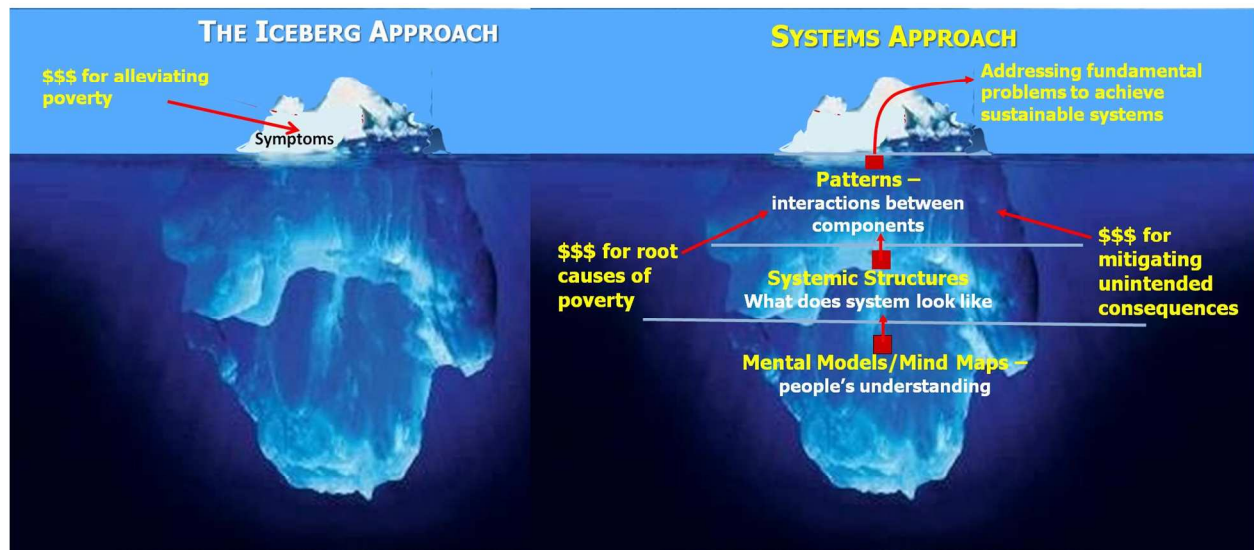


Figure 1 The Iceberg Approach versus a Systems Approach

In this model, events or symptoms (those issues that are easily identifiable) represent only the visible part of the iceberg above the waterline. Most decisions and interventions currently take place at this level, because ‘quick fixes’ (treating the symptoms) appear to be the easiest way out, although they do not provide long lasting solutions. However, at the deeper (fourth) level of thinking that hardly ever comes to the surface are the ‘*mental models of individuals and organisations that influence why things work the way they do. Mental models reflect the beliefs, values and assumptions that we personally hold, and they underlie our reasons for doing things the way we do*’ (Maani and Cavana 2007, p.15).

Moving to the third level of thinking is a critical step towards understanding how these mental models can be integrated in a systems structure that reveals how the different components are interconnected and affect one another. Thus, systemic structures unravel the intricate lace of relationships in complex systems.

The second level of thinking is to explore and identify the patterns that become apparent when a larger set of events (or data points) become linked to create a ‘history’ of past behaviours or outcomes and to quantify or qualify the relationships between the components of the system as a whole.

The systems thinking paradigm and methodology embrace these four levels of thinking by moving decision-makers and stakeholders from the event level to deeper levels of thinking and providing a systemic framework to deal with complex problems (Maani and Cavana 2007).

The application of systems thinking has grown extensively and encompasses work in many diverse fields and disciplines such as, to mention but a few, management (Jackson, 2003),

business (Sterman 2000; Walker, Stanton et al. 2009), decision making and consensus building (Maani and Maharraj 2004), human resource management (Quatro, Waldman et al. 2007), organisational learning (Galanakis 2006), health (Newell 2003; Lee 2009), commodity systems (Sawin, Hamilton et al. 2003), agricultural production systems (Wilson 2004), natural resource management (Allison and Hobbs 2006), environmental conflict management (Elias 2008), education (Hung 2008), social theory and management (Mingers 2006), and food security and population policy (Keegan and Nguyen 2011). This paper is the first to demonstrate how a comprehensive systems thinking approach, embedded in a cyclic Evolutionary Learning Laboratory (ELLab) framework, can be used to deal effectively with complex issues in a variety of contexts.

ESTABLISHING A SYSTEMS-BASED EVOLUTIONARY LEARNING LABORATORY

The Learning Laboratory (LLab) is a process, as well as a setting, in which a diverse group of participants engage in a cyclical process of thinking, planning, action and reflection for collective learning towards a common good. It is an environment where policy makers, managers, local facilitators, and researchers collaborate and learn together to understand and address complex problems of common interest in a systemic way (Maani and Cavana 2007). The ultimate goal is to achieve coherent actions directed towards sustainable outcomes.

The Evolutionary Learning Laboratory (ELLab) is a seven step iterative process (Figure 2) of group thinking and acting in which the participants engage in well defined activities and thus learn together in an ‘experimenting lab’ environment about how best to deal with the complex multidimensional and multi-stakeholder problems they are facing. Although it builds on

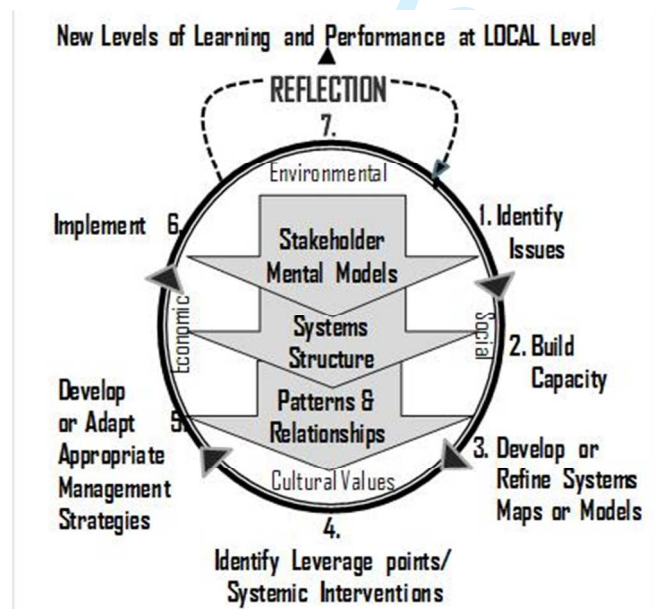


Figure 2 Evolutionary Learning Laboratory for Managing Complex Issues

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4 evolutionary design principles as described in the work of Banathy (1996) and the concept of
5 evolutionary leadership developed by Laszlo (2001), the process of establishing an ELLab
6 (Figure 2) could be regarded as a unique “methodology” to collaboratively integrate and use
7 existing and future knowledge to help manage complex issues. It starts at the ‘Fourth level of
8 thinking’ with an **issues workshop (step 1)** and a series of forums with specialist groups to
9 gather the mental models of all stakeholders involved in the issue under consideration, their
10 perceptions of how the system works, what they regard as barriers to success and drivers of
11 the system and possible strategies (solutions) to overcome these problems.
12
13

14 This is followed by implementing the ‘Third level of thinking’ through follow-up **capacity**
15 **building (step 2)** sessions during which the participants (all stakeholders) learn how to
16 integrate the various mental models into a **systems structure (step 3)**. The Vensim software
17 program (Systems 2011) is a valuable tool for the development of a systems model (Causal
18 Loop Diagram) of the issue under consideration. This learning step is of particular importance
19 in order for all involved to take ‘ownership’ of the systems model.
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21

22 Once completed, the participants move to the ‘Second level of thinking’ by **interpreting and**
23 **exploring the model for patterns**, how different components of the model are interconnected
24 and what feedback loops, reinforcing loops and balancing loops exist. This step aims to assist
25 relevant stakeholders to develop an understanding of their interdependencies and the role and
26 responsibility of each stakeholder group in the entire system. The main barriers and drivers of
27 the system are discussed in more detail, which provides the stakeholders with an opportunity
28 to develop a deeper understanding of the implications of coordinated actions, strategies and
29 policies. Overall, this process provides all stakeholders with a better understanding of each
30 other’s mental models and the development of a shared understanding of the issue(s) under
31 consideration.
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35 The interpretation leads to the **identification of leverage points for systemic intervention**
36 **(step 4)**. Leverage points are places within a complex system (e.g. an economy, a living body,
37 a city, an ecosystem) ‘*where a small shift in one thing can produce big changes in everything*
38 *... leverage points are points of power*’ (Meadows 1999, p.1). Senge (2006, p.64) also refers
39 to leverage points as the ‘*right places in a system where small, well-focused actions can*
40 *sometimes produce significant, enduring improvements*’. Identification of leverage points
41 greatly assists the devising of systemic interventions (finding systems based solutions) that
42 will contribute to the achievement of goals or solving problems in the system under
43 consideration.
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47 The outcomes are used to develop a refined systems model, which forms at the same time an
48 **Integrated Master Plan (step 5)** with systemically defined goals and strategies (systemic
49 interventions). In order to operationalise the master plan, Bayesian Belief Network (BBN)
50 modeling (Cain, Batchelor et al. 1999; Smith, Felderhof et al. 2007) is used to determine the
51 requirements for implementation of the management strategies; the factors that could affect
52 the expected outcomes; and the order in which activities should be carried out to ensure cost-
53 effectiveness and to maximize impact.
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4 The process of developing good policies and investment decisions is based on the best
5 knowledge (scientific data and information, experiential knowledge, expert opinions) that is
6 available at any point in time. The systems model can be used to test the possible outcomes of
7 different systemic interventions by observing what will happen to the system as a whole when
8 a particular strategy or combination of strategies is implemented, that is before any time or
9 money is invested in actual implementation.
10

11
12 Of particular value is the ability through BBN modeling to also ‘back-cast’. That is, the goal
13 is set at a 100% probability that it will be achieved and the model back-casts and points out
14 which of the components, actions or conditions have the most influence on the achievement
15 of the goal. This is a powerful way of determining where to invest time and resources, instead
16 of having only a list of recommendations, without an understanding of how they are
17 interconnected, which ones are the most important to invest in and in what order the strategies
18 should be implemented to ensure an efficient and cost-effective plan of action.
19

20
21 Once the systemic interventions have been identified and an operational plan has been
22 developed, the next step for the people who are responsible for the different areas of
23 management is to **implement the strategies and/or policies (step 6)** that will create the
24 biggest impact. Targets are determined and monitoring programs are implemented to measure
25 and/or observe the outcomes of the strategies and policies. In many cases it only requires an
26 adjustment of existing monitoring programs to comply with the targets set within the ELLab
27 process (e.g. to include factors to be measured that were used in the construction of the
28 Bayesian Management Model).
29
30

31
32 Because no systems model can ever be completely ‘correct’ in a complex and uncertain world
33 and unintended consequences always occur, the only way to manage complexity is by
34 **reflecting (step 7)** at regular intervals on the outcomes of the actions and decisions that have
35 been taken to determine how successful or unsuccessful the interventions are and to identify
36 unintended consequences and new barriers that were previously unforeseen.
37

38
39 The iterative process serves as a valuable informal co-learning experience and leads to new
40 levels of capability and performance. Working in this way as a coalition is the most effective
41 way to deal with complex issues, because the methodologies and processes acknowledge that
42 complex problems are multi-dimensional and have to involve all stakeholders, they require
43 cross-sectoral communication and collaborative approaches to resolve, and deal with many
44 uncertainties that need adaptive management approaches as more knowledge becomes
45 available through the iterative process of learning by doing.
46
47

48 **USING ELLABS TO DEAL WITH COMPLEX ISSUES IN A VARIETY OF** 49 50 **CONTEXTS**

51
52 As mentioned above, the ELLab approach is generic and can be used in dealing with any
53 complex issue, regardless of its context (e.g. organizational, natural or social systems) or
54 discipline area under consideration (e.g. business, health, engineering, education, marketing
55 and so on). In the following sections four case studies are used to demonstrate four diverse
56 examples of the application and implementation of the ELLab approach.
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1. Sustainable Development of a UNESCO Biosphere Reserve in Vietnam

Biosphere reserves (BRs) are sites recognized under the UNESCO Man and the Biosphere (MAB) program to demonstrate innovative state-of-the-art approaches to conservation and sustainable development. A comprehensive description of the origin and the evolution of the BR concept is presented in a paper (Ishwaran, Persic et al. 2008). There are currently 580 BRs in 114 countries (UNESCO 2012). UNESCO has recommended the launch of pilot projects to use BRs as learning laboratories to address the gap between BR knowledge systems (scientific, experiential, and indigenous) and the imperative for wider sustainable development. In this regard, the first pilot project, the Cat Ba Biosphere Reserve (CBBR) sustainability project in Haiphong City, Vietnam, has been initiated (Nguyen, Bosch et al. 2011). The project focuses on the interconnectedness of environment, tourism, livelihood of people and economic benefits, and the adoption of policies and processes by government and management bodies to ensure that long-term sustainable management will become institutionalised and ongoing.

Identify issues. Two workshops were conducted in March and October 2007 (Bosch, Maani et al. 2007) with a range of stakeholders to gather their mental models on the key issues and challenges that Cat Ba Island is facing. These include waste treatment, pollution, the high number of floating farms, overuse of underground water, strong growth in tourism, lack of fresh water and electricity (especially in the summer – tourist season), lack of skilled labour for the tourism industry, uncontrolled tourism development, insufficient infrastructure, lack of access to suitable markets for locally produced products, encroachment on conservation areas, lack of integrated planning, lack of capacity, environmental degradation, and poverty.

Build capacity. A two-month systems thinking and associated capacity building program was subsequently conducted in Australia (October and November 2008) for a group of ten policy makers, managers, and technical officers from different levels of government, across sections of agencies and an NGO, engaged in different capacities in the management of the CBBR. The process and outcomes of this capacity building program have been reported in a recent paper (Nguyen, Graham et al. 2012).

Develop a systems model. During the capacity building program, participants worked with the research team to integrate the various issues identified in the issue workshops into a preliminary systems model. Subsequently, the model (Figure 3) was refined and validated by various relevant stakeholders (managers and rangers of Cat Ba National Park, hotel owners, farmers, local people, and officials from different government departments) in a series of workshops, focus group discussions and in-depth interviews conducted in Haiphong city and on Cat Ba Island at the end of 2008 and early 2009. This involvement in the evaluation of the model was critical because it led to taking ‘ownership’ of the model and enhanced the ability of stakeholders to understand and carry out future intervention strategies and actions aimed at improving the system for sustainable outcomes.

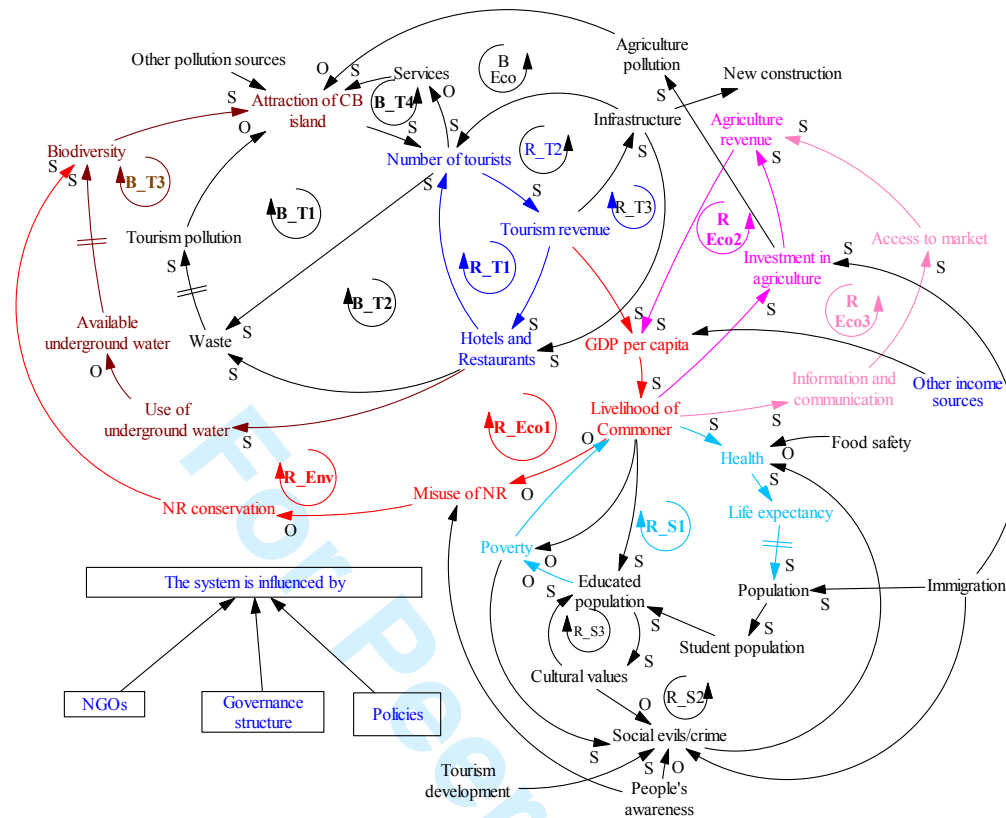


Figure 3 Systems model of CBBR – A Platform for Collaboration (Adapted from Nguyen, Bosch et al. 2011)

Legend: S (same direction), O (opposite direction), R (reinforcing), B (balancing), T (Tourism), Eco (Economic), Env (Environment), S (Social), 1,2,3 refer to loop number, e.g. R_T1 (Reinforcing loop no.1 of Tourism)

Figure 3 illustrates the identified interrelationships and interdependencies amongst the key components of the system. The systems model represents a ‘big picture’ of the CBBR system and provides a useful platform for learning, collaboration and decision making for relevant stakeholders including policy makers, researchers, managers, practitioners and local people.

Identify leverage points and systemic interventions. A follow up workshop was conducted in Haiphong City in May 2009 with the main objective to identify key leverage points and areas for systemic interventions for sustainability – based on the systems model of the CBBR and its associated systems archetypes. Systems archetypes ‘reveal an incredibly elegant simplicity underlying the complexity of management issues... [they allow us] to see more places where there is leverage in facing difficult challenges, and to explain these opportunities to others’ (Senge 2006, p.93). Four systems archetypes were identified in the systems model of the CBBR – ‘limits to growth’, ‘fixes that fail’, ‘tragedy of the commons’, and ‘shifting the burden’. These archetypes are discussed in detail by (Nguyen and Bosch 2012)) and not repeated in this paper.

The leverage areas require systemic interventions that are deemed critical for the long-term sustainability of the CBBR. Those identified included cross-sectoral collaboration;

development and implementation of government plans; capacity building for decision makers, managers, and local people; waste management and treatment; people's awareness; conservation of endangered species; investment for agriculture; improving the livelihood of commoners; and tourism development. These leverage areas form the basis for integrated projects and policies covering multiple aspects of the sustainability of the CBBR, including social, economic, cultural, and environmental well being.

Develop action plans. A series of Bayesian models were constructed to develop action plans for the identified leverage areas and systemic interventions. An example of these models is illustrated in Figure 4.

The Bayesian model developed in this study (Phan 2011) is designed as a decision support tool to assist the management board of the CBBR and Cat Ba National Park in developing feasible management and action plans for the conservation and protection of the population of an endangered species (Serow – mountain goat) in the CBBR.

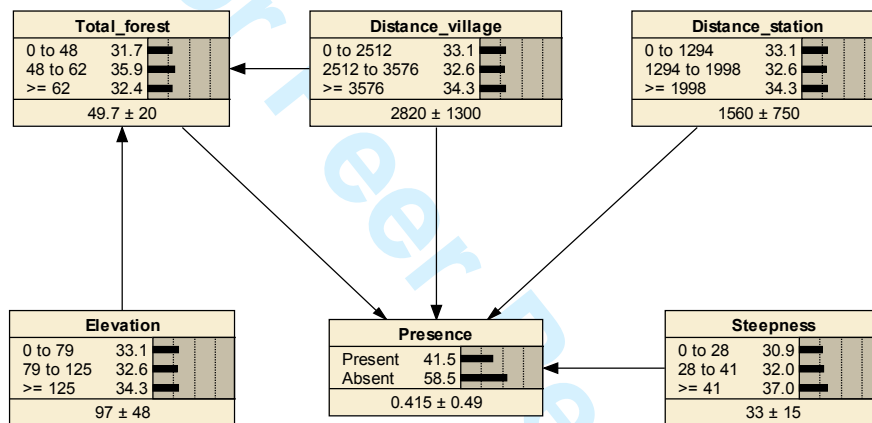


Figure 4 Bayesian model of Serow occurrence in the CBBR (Adapted from Phan2011)

Short-term and long-term measures for this endangered species are needed. In the short-term, stronger engagement of local people, especially the potential poachers, to participate in Serow protection is necessary. Intensifying patrol activities in prioritized conservation areas are needed to avoid any further loss of individual animals. Simultaneously, more stringent law enforcement by authorities and adopting more severe punishment measures for illegal hunting are required.

In the long-term, providing opportunities to improve the financial position of the poor through technical support and education is one of the most important and sustainable solutions to improve the livelihoods of people on the island. This would avoid the increasing impact of local people on the resources of the National Park. Raising the conservation awareness of local residents and improving the knowledge and management capacity on biodiversity conservation and conservation planning of managers of the Cat Ba National Park are vital to ensure an effective conservation outcome in the CBBR (Phan 2011).

Implementation. A series of strategies are currently being implemented to improve the livelihood of the commoner. A comprehensive model has also been developed for

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4 sustainable tourism development as a mechanism for improving the livelihoods of people on
5 the island (Mai 2012), while models for improving waste management and agricultural
6 market access are currently being completed. Several small projects and actions have also
7 been undertaken to address the various leverage points and systemic intervention strategies
8 that had been identified from the systems model and its associated systems archetypes. These
9 include building the capacity of the rangers to systemically manage the National Park;
10 conducting a social welfare study relating to community development in the CBBR;
11 producing an annual Cat Ba Ecosystem Health Report Card; establishing community
12 partnerships in natural resource management and environmental protection; and relocating the
13 floating farms away from main tourism areas and out of the national marine protected areas.
14
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17 **Reflection.** The early and consistent involvement of key decision makers and
18 stakeholders (nearly 200 participants to date) has been of paramount importance for the
19 successful formation and implementation of an ELLab for sustainability in the CBBR. This
20 involvement will be of significant importance for the seamless continuity and sustainability of
21 the project.
22

23
24 Frequent reflection on the successes and failures of implemented strategies (systemic
25 interventions) has led to new knowledge and ideas. For example, to enhance awareness of
26 sustainable practices and increasing employment of locals, a CBBR brand system has been
27 introduced that is awarded to products (e.g. fish sauce, honey) and businesses (e.g. tourist
28 boat services, recreation parks, hotels, guest houses and restaurants) that complies with a set
29 of relevant criteria such as business registration, water saving mechanisms, employing local
30 people, fire safety standards, food safety and hygiene standards. The collaborative learning
31 process has also led to a strong realisation that the CBBR management regulations need
32 revision, especially to improve integrated planning and actions across different sectors of
33 society.
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36 **2. Policy Design for Child Safety in Japan**

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38 In OECD member countries, more than 125,300 children died from injuries from 1991 to
39 1995, which amounts to 39% of all deaths. Japan was ranked as a medium risk performer in
40 deaths by drowning, fire, falls and intentional harm, whereas deaths due to car accidents were
41 significantly lower than in other countries (UNICEF. 2001). Japanese society often regards
42 parents as the only people responsible for child safety. Japanese parents tend to feel isolated
43 and frustrated, because there is a clear lack of a coordinated approach with other stakeholders
44 in the society to help prevent injury to their children (Kakefuda, Yamanaka et al. 2008). The
45 complexity of this issue warranted a participatory systems analysis approach to create
46 possible solutions by embedding the systems model in an ELLab context in order to
47 'experiment' with potential solutions that could lead to better policies for a safe and secure
48 society.
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52 **Identify the issues.** The mental models of a wide variety of relevant stakeholders
53 about the issue were obtained from a focus group meeting (conducted in September 2011) to
54 identify and visualize all factors related to child injuries.
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Build capacity and develop a causal loop model. A workshop was held in September 2011 during which various stakeholders collaboratively constructed a causal loop diagram to identify the components of the system and to explore the interactions and relationships between them. The facilitator of the group had undergone intensive training in systems methodologies, which made it possible to structure the mental models of the various participants into a model.

Identify leverage points and systemic interventions. Special attention was given to the identification of reinforcing and balancing loops in order to assist in the identification of possible leverage points for systemic interventions. This was carried out through visual observation and discussions between participants on the potential degree of change that could be caused by changes to particular components of the system. Seven systemic intervention points were identified (in red font, Figure 5): safer product designs, caring volunteers to support frustrated parents, closer involvement of social workers, more integrated approach by government, more pediatricians, shortening of the time between an accident and hospitalization, and better care of students in schools.

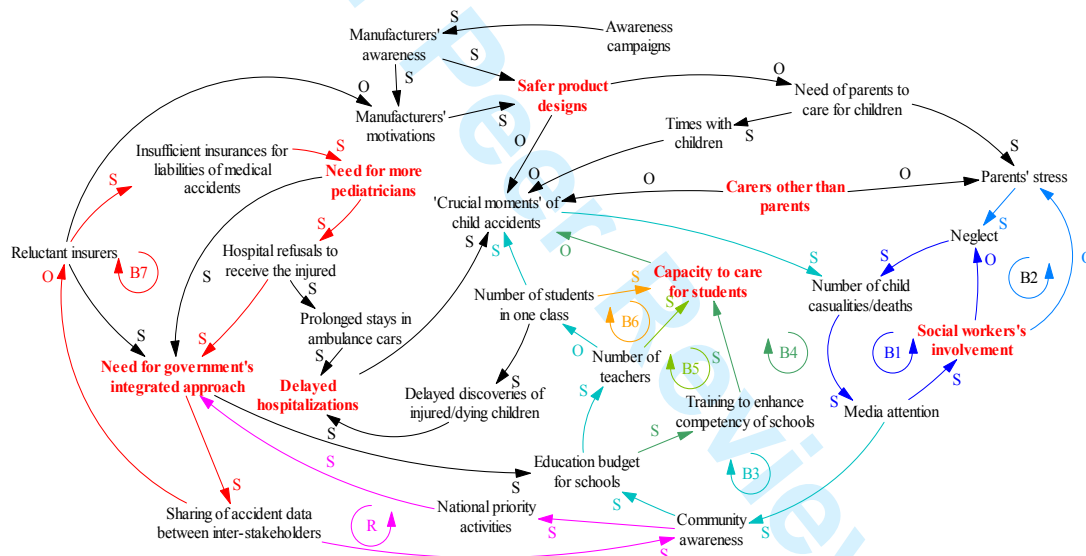


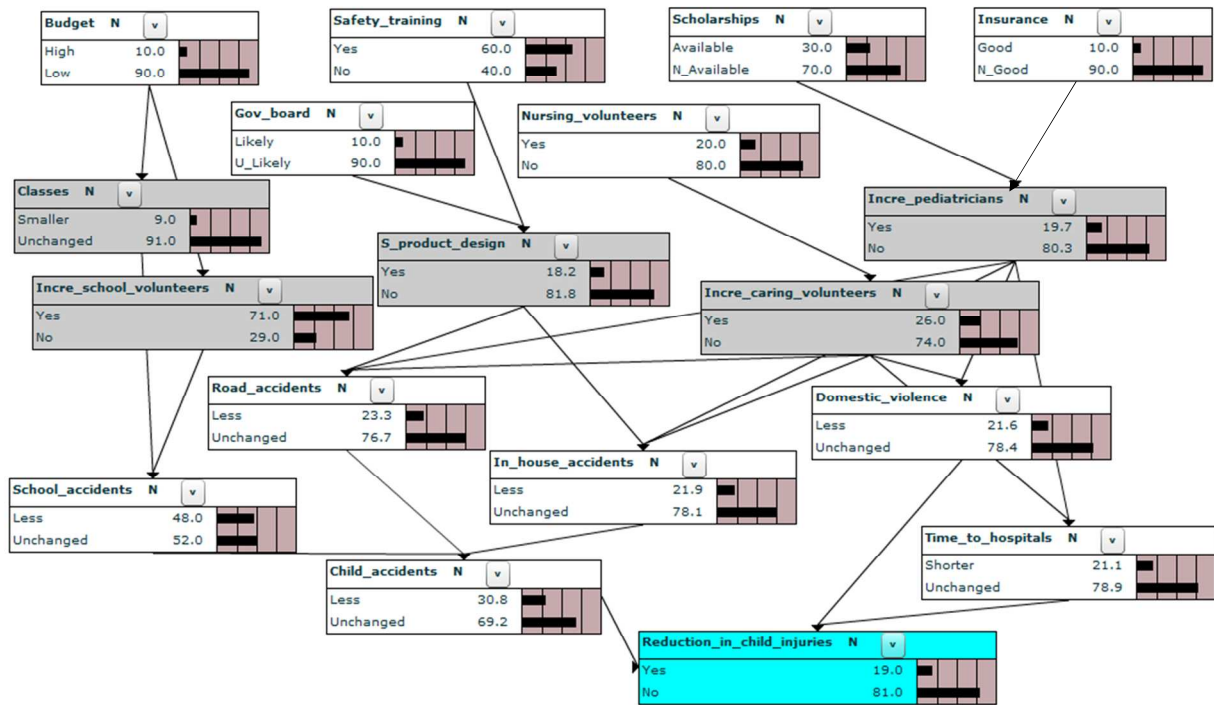
Figure 5 Causal Loop Diagram and Identified Systemic Interventions Points for Child Safety in Japan

Develop action plans. The participating stakeholders used the seven systemic intervention points to structure a Bayesian Belief Network model for designing policies on child safety (Figure 6). The model was populated by various stakeholders who jointly used their experiential knowledge to decide on the probabilities of how the parent nodes would affect the child nodes. For example, what are the probabilities that more scholarships and better insurance policies will lead to an increase in the number of pediatricians; how would designer training and a government that could test the designs change the probability that the design of products will be safe; and what is the probability that there will be less school accidents if there are more school volunteers and smaller classes.

Through this co-designing process, the stakeholders recognized that the Bayesian model, populated with information about the current conditions, indicated that there is only a 19.0% probability that the rate of child injuries will be reduced (Figure 6a).

A sensitivity analysis of the model indicated that the most effective parameter to reduce child injuries was to increase the number of volunteer nursing councilors (Figure 6b). The model indicated that if the number of volunteer nursing councilors is set at 100%, the probability that less child injuries will occur will rise to 46.7%. However, by also providing designer training in child safety, establishing a government board for product evaluation, reducing the size of classes in schools and having sufficient numbers of pediatricians will increase the probability to have less child injuries to about 72%. Therefore, although a policy to increase the number of volunteer nursing councilors would make a big difference, these additional four systemic interventions were also identified as important to significantly reduce child injuries (Step 5).

(a)



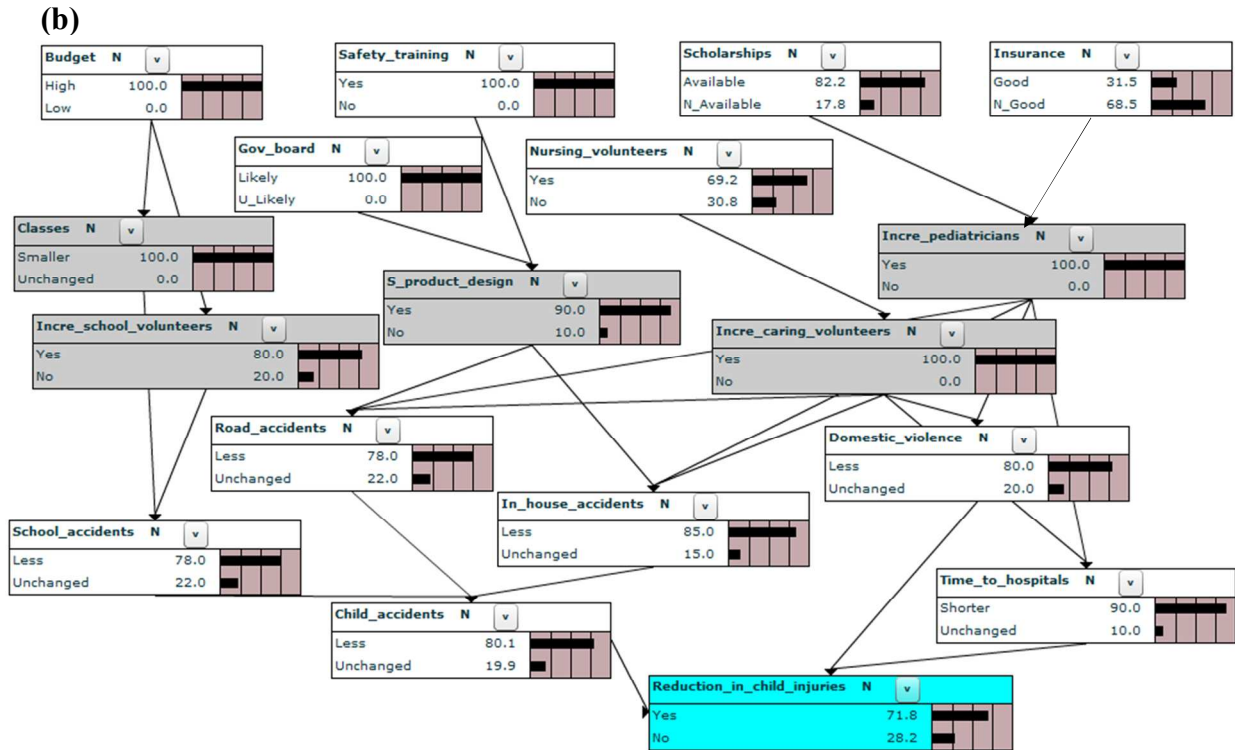


Figure 6 Populated Bayesian Model for Child Safety: (a) Current conditions and (b) Indicating the main leverage points and systemic interventions that were identified

Implementation. A change in the policy to increase voluntary nursing staff and implementation of the additional systemic interventions have been proposed in order to ‘experiment’ how these interventions will affect child injuries.

Reflection. The models have been constructed with the best experiential knowledge available at the time. These models are therefore embedded in the cyclical process of ‘experimenting’ and reflecting through which new knowledge will be created. Strategies will be refined in a co-learning environment to find the best solutions for this complex problem over time – forming the ELLab.

3. Enhancing the Reputation of a University School in Japan

The Graduate School of Systems Design and Management (SDM) at Keio University in Japan was established in 2008. This school is rapidly becoming a focus point in the Asia Pacific region for its mission to educate students who can solve complex and large scale problems in any system ranging from social (human dimensions) to highly technological issues. The School is building its foundation on systems and design thinking and has a strong focus on industry and community needs, while taking into account that all problems are embedded in a complex web in which environment, security and safety, health and welfare, economics, politics and culture are all highly interconnected. What makes the school particularly unusual is the fact that it attracts students for Masters and PhD programs from all different disciplinary backgrounds (Figure 7), which creates a collaborative learning environment for the evolution of creative and innovative thinking and systems design.

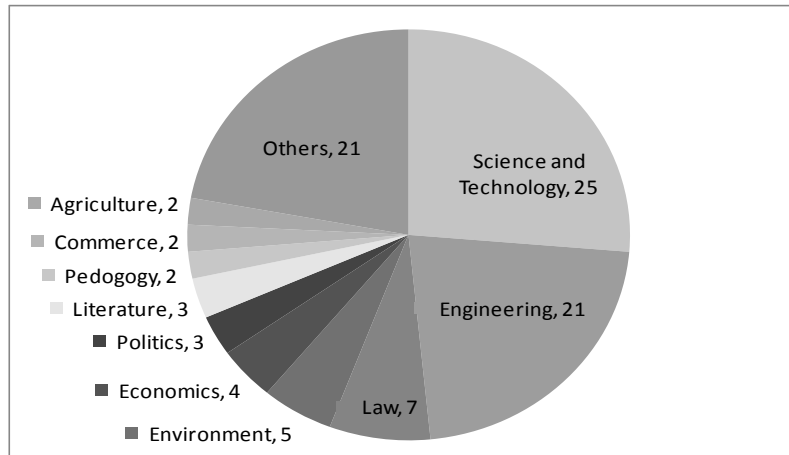


Figure 7 Diverse backgrounds of students in the 2012 postgraduate class

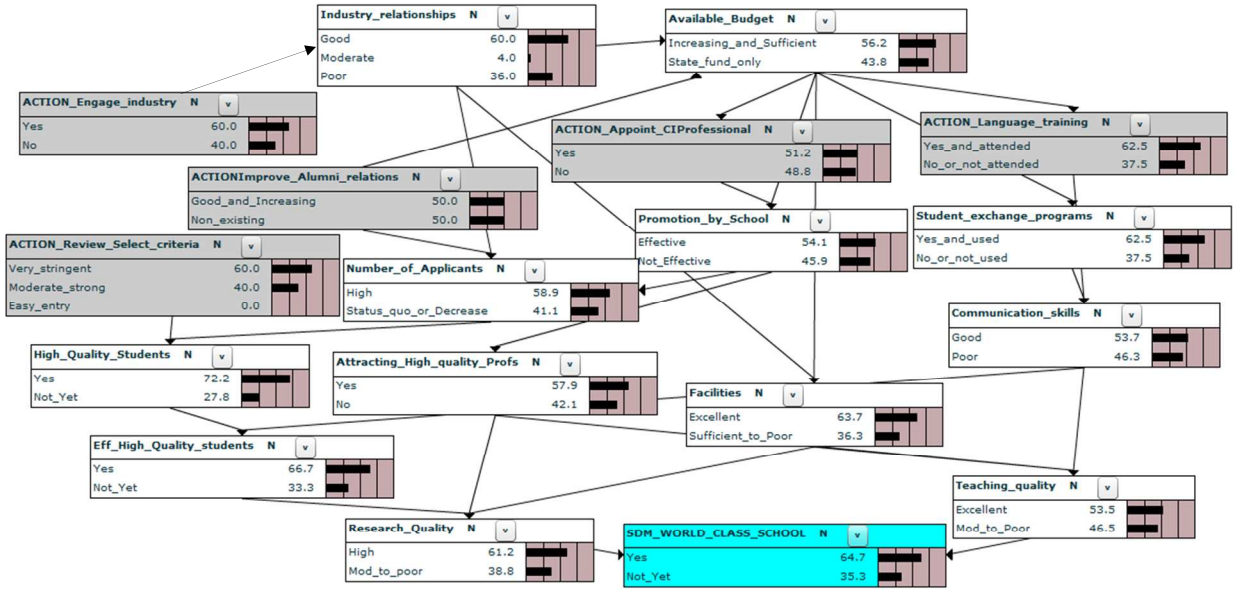
In April 2011 SDM decided to revisit its initial vision and strategies in order to develop a 'clearer and more committed operation' and to be recognized as a world class institution in the area of systems design. Because of the complexity of this task and the intention of the school to find long lasting solutions, rather than quick fixes, SDM decided, as part of this process, to establish the school as an ELLab.

Identify the issues and build capacity. The first step was to hold a workshop represented by a number of students and staff members who were all trained (**step 2**) in the development and interpretation of systems models. The participants' mental models on how they believe the school can improve its reputation, the drivers and barriers in achieving this and possible solutions to overcome the barriers were collected.

Develop and interpret a Bayesian Belief Network model. In this particular case the mental models were integrated by directly structuring them into a conceptual inference diagram, which formed the basis for a Bayesian Belief Network (BBN) model (Figure 8).

The probability tables were populated with the experiential knowledge (mental models) of the participants to form a first draft model that described the main components of the system and how they are related to each other (**step 3**). Testing of different scenarios by changing different components of the model and combinations of components facilitated an evaluation of how well the model reflects the real situation. Based on this the probability tables were revisited and refined until the model provided a realistic description of the current school and the system in which it operates.

(a)



(b)

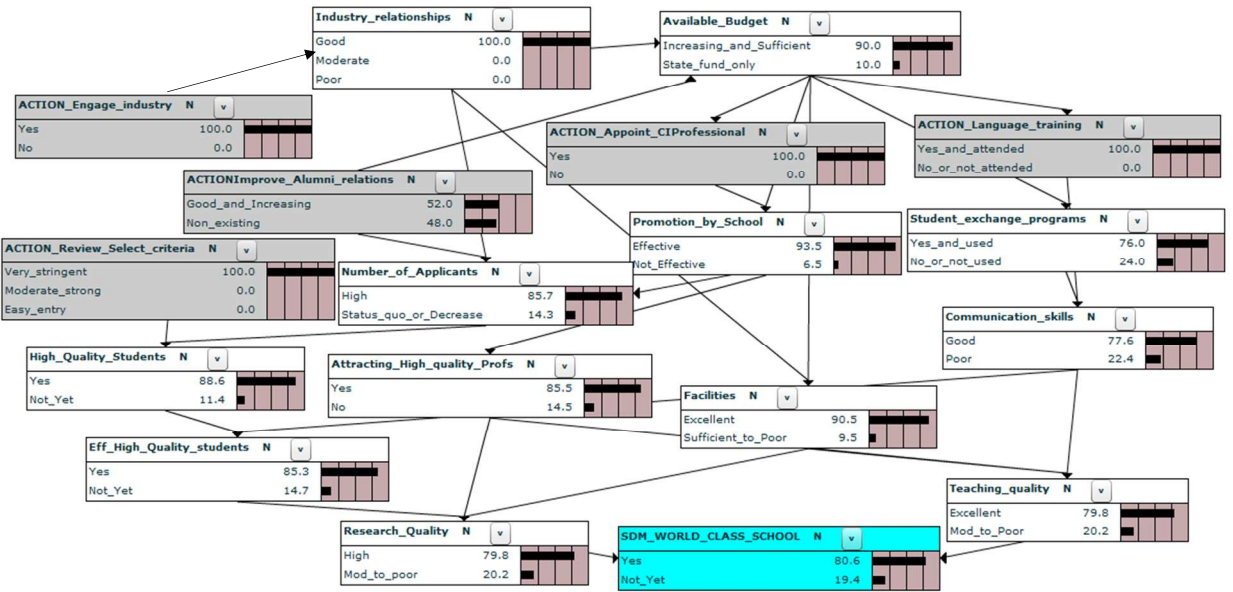


Figure 8 First draft BBN Model to enhance the reputation of the school: Current situation (a) and with systemic interventions implemented (b)

Identifying leverage points and systemic intervention strategies. Patterns and relationships were explored by changing each of the components in the ‘what can we do’ or ‘Action’ nodes of the model individually to observe how such a change affects the end goal of SDM to be recognized as a world-renowned school with a reputation of excellence.

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4 Appointing or consulting a Competitive Intelligence Professional that can provide appropriate
5 intelligence for different audiences (e.g. industry, potential students) for more effective
6 promotion and marketing of SDM (the probability for this to occur changed from 54% to 90%
7 – comparing Figure 8 (a) and (b)) will have the largest single effect on achieving the goal to
8 become a world class school, increasing the probability from 64% to 72%. Other outcomes
9 that will improve the probabilities for achieving the end goal include an increase in the
10 number of applications (from 58 to 86%) and the probability that more high quality professors
11 will be attracted to SDM (from 57 to 85%). A further improvement of the relationships that
12 SDM already has with industry will have the second largest effect on the goal. This will lead
13 to the probability to increase the budget of SDM from 56% to 80%; for students to have
14 access to better research facilities from 63% to 90%; and the ability to fund language training
15 from 52 to 72%.

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19 Implementing both the above actions will lead to an increase in the probability to achieve the
20 end goal from 64 to 76%. This probability can further be increased to 80% by reviewing the
21 criteria for entry to SDM. More stringent criteria will lead to a higher probability of high
22 quality students and if they have good communication skills (through language training) and
23 work under the supervision of high quality professors (who are attracted by good promotion)
24 the probability for high quality research will increase from the current 61% to almost 80%.

25
26
27 **Implementation.** In summary, to achieve SDM's goal of being recognized as a world
28 class institution, investment should first be in appointing or consulting a Competitive
29 Intelligence Professional and in further enhancing its relationships with industry. A
30 combination of these two actions will have the biggest effect on the end goal. Other actions
31 that could be implemented, but would not significantly contribute to achieving the end goal,
32 include the provision of language training and more stringent selection criteria to ensure high
33 quality students with good communication skills.

34
35
36 The school is consulting an expert in the area of competitive intelligence (one of its staff
37 members) to develop effective marketing and promotion material and mechanisms for
38 different types of audiences (e.g. large companies, potential students, government
39 departments). Stronger collaboration with industry is being established through the selection
40 of real issues in different companies and government agencies for student assignments and
41 Masters projects (e.g. Toshiba, NEC, Yokohama City).

42
43
44 **Reflection.** The effects of changes in those parameters of the model that were
45 identified during model development as being affected by the actions undertaken are being
46 monitored (e.g. increase in the school budget, language competency, number of student
47 enrolments, and availability of quality research facilities in industry). The outcomes of these
48 will be used to refine the first draft model – starting the cyclic process of 'experimenting' and
49 adapting of the SDM ELLab.

50 51 52 **4. Managing Tree Density in the Rangelands of Northern Queensland, Australia**

53
54 Much of Australia's grazing land is comprised of woodland. Trees and native pastures coexist
55 in these ecosystems, where they compete for water, nutrients and sunlight. However, there is
56 also a mutually beneficial relationship between trees and pastures, provided the balance is
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right. When a favourable tree-grass balance exists, trees provide shade and shelter for livestock and support biodiversity. They also carry out key ecosystem functions, such as water and soil nutrient cycling, and contribute to healthy land condition by preventing erosion and salinity, storing carbon and enhancing soil condition (Liedloff and Smith 2010).

There is an increasing recognition of the role that trees play in grazing systems, which has led to a demand for sustainable woodland management. Of particular importance is the management of tree cover thickening in the tropical savannas, which has the potential to change catchment hydrology (Krull, Bray et al. 2007), carbon stocks (Burrows, Henry et al. 2002; Henry, Danaher et al. 2002), pasture biomass available for grazing animals (van Langevelde, van de Vijver et al. 2003) and wildlife habitat (Tassicker, Kutt et al. 2006). Tree thickening is therefore an important issue to many stakeholders, including pastoralists, conservationists, land managers and those interested in carbon markets, each with a wide range of opinions and vested interests in the process (Bosch, King et al. 2007).

The demand for better management of the complex interactions between different factors and components of the tree thickening system has led to the establishment of an Evolutionary Learning Laboratory for Sustainable Woodland Management.

Identify issues. Several workshops were held during 2005 in different localities in the rangelands of Northern Queensland. Graziers, researchers and extension officers discussed the tree thickening problem and identified the factors that they believed would influence tree density. Possible management actions and non-manageable factors that might influence density were also identified and discussed.

Build capacity and develop a model. The knowledge of the workshop participants was captured by mapping out an influence diagram. The process allowed for the integration of the different mental models of the stakeholders (varying perspectives and divergent views). While divergent views occur, the appreciation of each other's views gained through 'mapping the system' helped stakeholders to develop a common understanding of the management system.

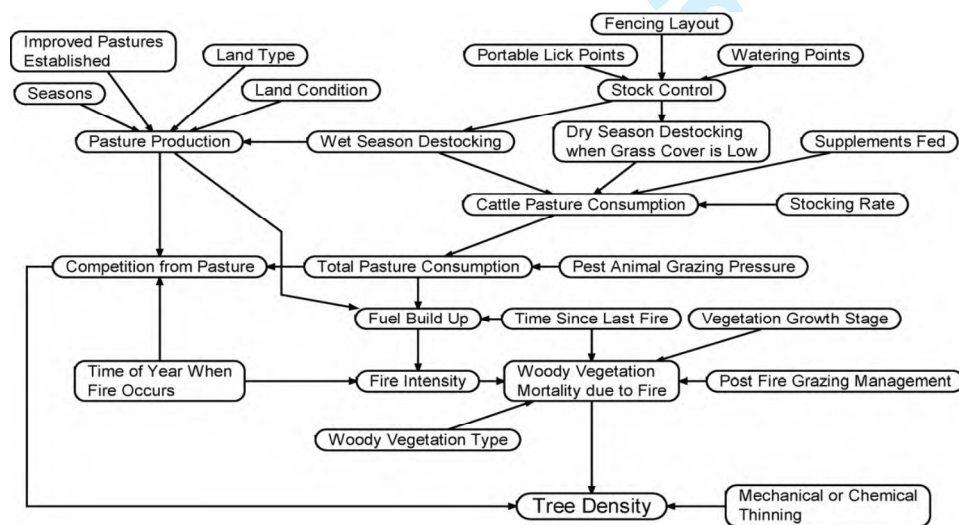


Figure 9 Influence Diagram of Issues related to Managing Tree Density (Adapted from Bosch et al.2007)

The influence diagram (Figure 9) provided a structure through which stakeholders could express and discuss their understanding of the cause and effect relationships between management actions, controlling factors and resource management outcomes or goals. The diagram also assisted the stakeholders in identifying how their knowledge contributed to a better understanding of the overall management system and to appreciate how other stakeholders understand the links between management actions and outcomes (providing a mechanism for externalizing and internalizing knowledge). This co-learning process (capacity building) consists of individual stakeholders who are socializing and externalizing their knowledge within a group, combining this knowledge, and learning from each other (internalization) (Nonaka and Konno 1998).

The influence diagram was used as a framework for the development of a Bayesian Belief Network (BBN) model (Figure 10) through which it was possible to integrate experiential knowledge, scientific data and models to populate the BBN model. This processes ensured that the knowledge created by scientists became integrated with the understanding of systems by land managers, conservationists and other stakeholders.

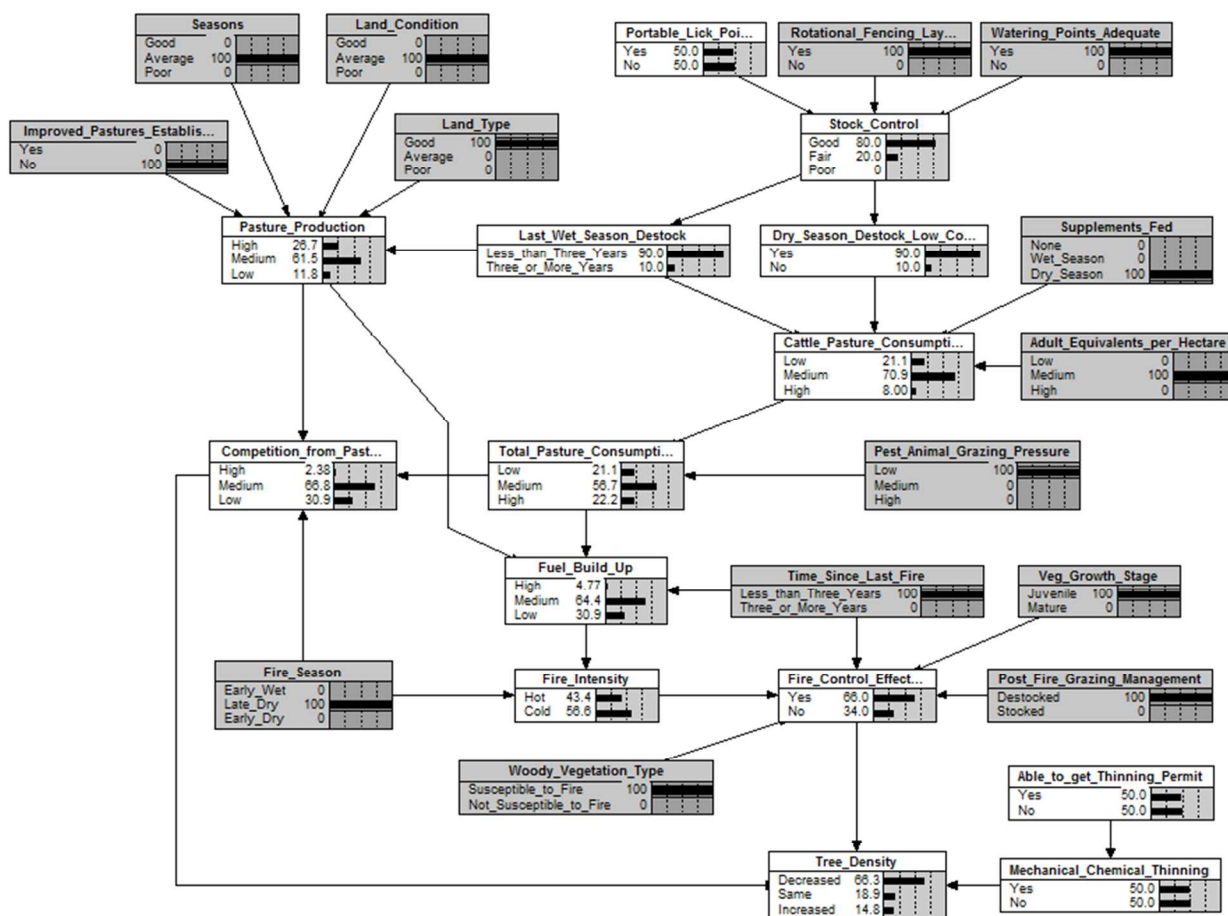


Figure 10 BBN Model for tree density containing alternative scenario (Adapted from Bosch et al.2007)

Figure 10 shows a completed BBN systems model for tree density management. Each node has two or more states and arrows represent the causal relationships between nodes.

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4 Conditional probability tables (CPTs) specify the relationships between the nodes. Bosch et
5 al. (2007, Table 1) described the CPT in an example of how fuel build-up and fire season
6 influence fire intensity. The first row represents the scenario where fuel build up is high
7 (>1800 kg/ha) and the fire season (time of fire) is 'late_dry' (October/November). *'Under this*
8 *scenario there is a 100% chance that fire intensity will be hot. By completing the probability*
9 *table for each node in the BBN, available data, information and experiential knowledge are*
10 *integrated in a systematic way. The result is a knowledge base and a dynamic systems model*
11 *that can assist stakeholders (particularly managers) in decision-making through analysing*
12 *different scenarios'* (Bosch, King et al. 2007, p.220).
13
14

15 **Identify leverage points and systemic interventions.** An evaluation of the model
16 and identification of leverage points and systemic interventions that will affect the goal (avoid
17 thickening of tree density) was done by testing model behaviour with stakeholders through
18 applying different management scenarios and predicting the possible outcomes. Back-casting
19 was also used to identify which actions and factors would have the largest effect on the goal,
20 providing or confirming the systemic interventions identified during scenario analysis.
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23 The incidence of fire and the factors that determine the nature of fires were identified as the
24 most important leverage point for controlling thickening of trees. This conclusion was
25 verified by scientific data and models (Liedloff and Smith 2010) and experiential knowledge
26 of land managers. It was mentioned that where fire has been a regular feature within the
27 landscape, the removal of fire will often lead to woodland thickening. Grazed woodland
28 ecosystems evolved with fire, which suppresses tree thickening. Without a disturbance such
29 as fire, many land types will have a higher tree density.
30
31

32 **Develop management plan and implementation.** From the BBN model it was clear
33 that the most economic and environmentally sustainable way to control tree cover thickening
34 is with fire, provided conditions such as fuel load are satisfactory. The BBN model served as
35 a tool to identify possible management scenarios before actual implementation.
36
37

38 **Reflection.** The approach of stakeholder involvement and systems thinking described
39 above led to a model that represents the mutual understanding of stakeholders and their
40 current knowledge base for decision-making. However, this knowledge base is rarely perfect
41 because natural systems are complex, and their management takes place against a background
42 of continuous and unpredictable change in environmental, economic and social conditions.
43 Due to this, the uncertainties in achieving the desired resource management outcomes remain
44 high. However, new knowledge about management systems behaviour is continuously
45 generated through observation (monitoring) and the evaluation of outcomes of implemented
46 management strategies. Embedding the BBN model in the cyclic process of the ELLab
47 allowed for continuous improvement of the knowledge base, and its usefulness for managing
48 natural resources under uncertain and variable conditions.
49

50 Reflecting on management outcomes emphasised the importance of fire as a management
51 tool. It became clear that tree density and structure are constantly changing due to climatic
52 variation and the use of fire. In many regions a thickening of trees occurred during higher
53 rainfall periods and thinning during drought. Where fire has been a regular feature within the
54 landscape its removal often led to the thickening of tree cover. In extensive systems where
55 thickening has occurred, mustering costs have increased by up to 30% and production has
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suffered as pastures compete for scarce resources. It has become clear that the most economic and environmentally sustainable way to control woody thickening is with fire, provided conditions such as fuel load are satisfactory. This finding during the reflection stage has led to the development of a more detailed model that focuses on the influence of management and non-management drivers on woody vegetation change (Liedloff and Smith 2010).

THE GLOBAL EVOLUTIONARY LEARNING LABORATORY (GELL)

Once an Evolutionary Learning Laboratory has been established in each particular region or country, it will operate as a management tool for the reform and sustainable management of complex issues in their respective systems. As described in the above case studies, management strategies and policies are implemented and the ELLab runs 'Reflection' meetings (**step 7**) to discuss the outcomes (successes and failures) and decide how to change the management or how to adapt a policy. These reflection meetings will lead to new levels of learning and enhanced management performance in the different sectors of the system as a whole.

Each individual ELLab will also become part of the Global Evolutionary Learning Laboratory (Figure 11) and continually share the lessons it has learned with ELLabs (and other similar innovations) in other parts of the world, through the lenses of different political systems, cultures, etc. GELL is currently being enhanced with advanced e-technologies that will help it to serve as a platform for continuous sharing and co-learning, leading to new levels of learning and performance at regional and global level. It will also help individual ELLabs to learn more and perform better in their own countries, organisations, businesses and communities.

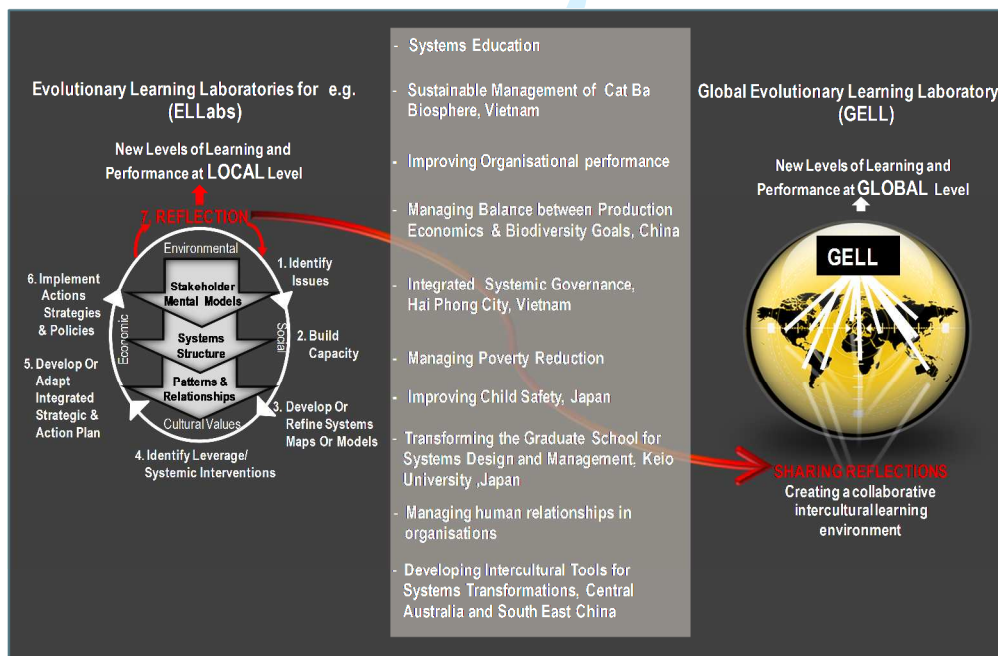


Figure 11 The Global Evolutionary Learning Laboratory (GELL)

CONCLUSION

Globally effective researchers, as well as existing and future leaders and managers, will need to understand complexity and how to deal with it in multi-stakeholder scenarios. Systems thinking is therefore the underlying paradigm and research approach. This paper has described the application of systems thinking in the establishment of Evolutionary Learning Laboratories for managing complex issues through enhancing cross-sectoral communication and collaboration, and promoting effective change. Each ELLab develops uniquely due to the political and cultural systems of each country, organisation or business. The Global Evolutionary Learning Laboratory can greatly enhance our capacity to address globalised issues, and serves as a global knowledge hub.

The establishment of ELLabs and the Global Evolutionary Learning Laboratory is an ongoing process. The research so far has achieved various active engagements at specific levels, local and global, including local communities, national park staff, local and national governments, the national Man and Biosphere committees in different countries, and the UNESCO Man and the Biosphere program (MAB). UNESCO/MAB has already acknowledged this approach as best practice for potential applications to more than 580 biosphere reserves globally (Nguyen, Bosch et al. 2011).

The research has helped to build the capacity of various people (relevant stakeholders) in different places where ELLabs are being established. The stakeholders are closely involved in all the different steps of the establishment of their respective ELLabs. This close involvement has enabled a shared vision amongst stakeholders and helped them to understand complexity and be able to identify the root causes of problems, rather than merely treating the symptoms. It has also helped them to develop solutions collaboratively over time, 'experiment' with them and be able to adapt when required through knowledge sharing and discussions with others. In addition, the close involvement has enabled the relevant stakeholders to take 'ownership' of the ELLab and to know how to operate it.

Having a 'champion' is another important lesson learned through the research. The authors have been fortunate to work with a champion (a key person in a leading position, who understands and supports the approach) in every site where an ELLab has been established. This is essential for the successful implementation and operation of the ELLab.

The key challenge in this research is securing funding to address the identified leverage points and systemic interventions. It is common for donors and funding agencies to provide funding for treating the 'symptoms' with quick fixes, in order to see (and show to the world) immediate results from their funding efforts. However, it could take several years for a systems based approach to achieve long-lasting sustainable outcomes by solving the root causes of problems. Finding the funds for a process with often non-tangible outcomes (such as a bridge, a school or a road) has proved to be a major challenge, especially for developing countries.

A further important challenge is the 'silo' structure of ministries and organisations in every country, which makes 'collaboration' a foreign concept. A paradigm shift is needed to move

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4 away from this kind of structure. Further research to institutionalise the ELLab concept,
5 leading to the use of collective intelligence in decision-making across sectors and
6 organisations and effective collaborative governance, has become a high priority.
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9 Computer-based modeling systems can be useful tools to explore and make management
10 action decisions that are more systemic than the decisions produced by traditional approaches.
11 Of particular importance is their ability to be used within a participatory process, to enable
12 knowledge capturing, testing and refinement of multi-stakeholders. Used in this way, a
13 computer-based modeling system (such as a BBN) can (a) provide a flexible modeling
14 environment, (b) allow uncertainty in knowledge to be expressed using probabilistic
15 relationships, (c) allow biophysical, economic and social variables (either quantitative or
16 qualitative) to be related, (d) enable a graphical (flow chart) interface that is easily understood
17 and facilitates communication between stakeholders and (e) be easily updated as new
18 knowledge emerges, without the need for specialist computer skills (i.e. nodes added or
19 removed, links changed and probabilities updated).
20
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22 In summary, a 'New Way of Thinking' can change the effectiveness of government
23 departments, businesses, organisations and communities in many ways:
24

- 25 • Better mutual understanding of the diverse mental models of different stakeholders;
- 26
- 27 • Moving away from traditional linear thinking that leads to quick fixes and treatment of
28 the symptoms, to long lasting systemic solutions that address the root causes;
- 29
- 30 • Ability to collaboratively identify leverage points and systemic interventions to
31 underpin systems-based master and strategic plans;
- 32
- 33 • Deep understanding of the interconnectedness between possible actions in order to
34 develop efficient and cost-effective management strategies;
- 35
- 36 • Working knowledge of cutting edge systems tools to test the outcomes of strategies,
37 including identification of unintended consequences – before actual implementation;
- 38
- 39 • Ability to use back-casting to identify those factors that will have the most influence
40 on the achievement of goals (knowing where and when to invest in the system);
- 41
- 42 • Using the Evolutionary Learning Laboratory as an ongoing process for continuous co-
43 learning and refinement of management strategies.
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