Outcome-Based Management for Sustainability

ARTICLE HISTORY
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ABSTRACT
EIA/SEA is effects-based management involving assessing adverse effects of proposed programs or projects and developing measures to avoid or mitigate adverse effects. Government has a regulatory role through assessment processes and monitoring compliance with conditions. However, EIA/SEA has not prevented environmental bottom-lines from being exceeded and has led to further environmental degradation. Sustainable development requires a proactive role by government for programs and projects to achieve targeted outcomes. Rather than relying on proponent-led projects and compliance with conditions, outcome-based management is needed. This involves sustainability strategies to meet multiple community outcomes, for programs and projects to be aligned with those strategies, and, auditing of implementation against achievement of outcomes. A systems approach is described for developing sustainability strategies through failure pathway analysis and management interventions to address critical variables where resilience thresholds are threatened. Implementation requires projects to be aligned with the strategies, management systems demonstrating how compatibility can be achieved, and, management plans for specifying measures to achieve the sustainability targets with independent auditing of plan adoption and outcome achievement.

KEYWORDS
Nested adaptive systems; Outcome-based management; Sustainability strategies; Sustainable development

1. Introduction

Environmental impact assessment (EIA) is "effects-based management". Proposed projects are assessed for adverse effects and the intent of EIA is to avoid, remedy or mitigate significant adverse effects. The concept is to allow resource use and development activities while operating within environmental limits (Figure 1). The role of government is primarily one of a regulator in managing the assessment process, setting conditions of approval and monitoring compliance with those conditions.

However, when environmental limits of resource availability or the cumulative effects of development are reached, then effects-based assessment of further development can only lead to rejection of that development if environmental limits are applied or impacts beyond environmental limits if development is approved. While EIA has brought the consideration of environmental factors into development decisions, the evidence from state-of-environment monitoring is that environmental outcomes are being compromised.

To achieve sustainable development when environmental limits have been exceeded requires proactive interventions to address environmental degradation, i.e. sustainability strategies (Figure 2). Sustainability strategies are needed to address the cumulative impacts of multiple users to achieve a satisfactory environmental outcome, i.e.

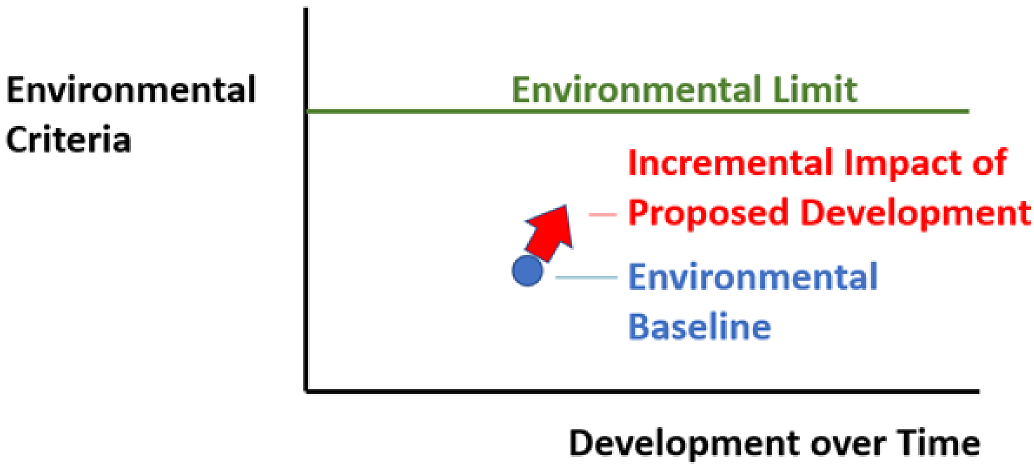

Figure 1. Impact Assessment: Incremental Impacts Within Environmental Limits

"outcome-based management".

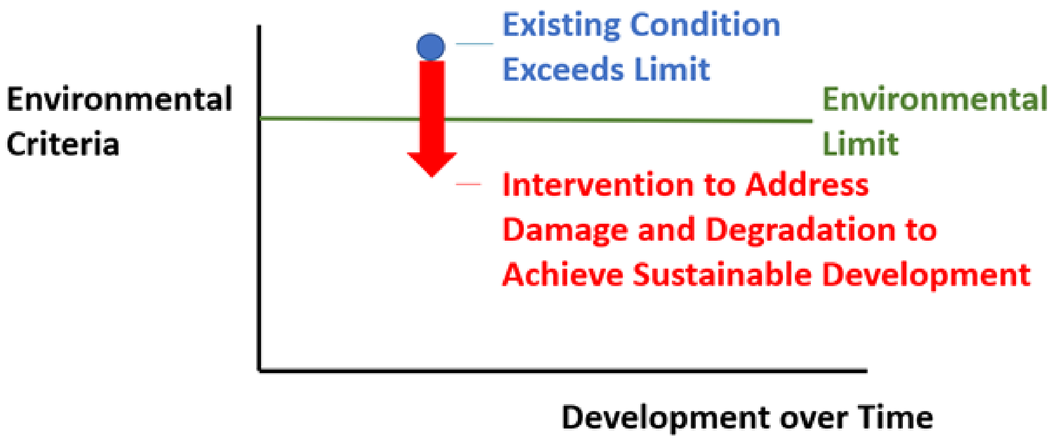

Figure 2. Sustainability Strategy: Interventions When Environmental Limits Exceeded

This requires analysis at the bioregional scale relevant to the cumulative impacts in advance of further development. It also requires the consideration of existing users who are likely to have current environmental approvals. This means it is not sufficient to rely on compliance with conditions and regulations, rather incentives are needed to foster change among existing users. It is not just the biophysical system associated with the environmental impacts that needs to be considered in developing a sustainability strategy but also the socio-economic system including resource users, affected people, the community and government institutions. Implementation of a sustainability strategy also needs a financial mechanism.

2. Systems Approach for Sustainable Outcomes

Nested adaptive systems analysis provides a framework for developing sustainability strategies (Jenkins (2018)). There are seven major elements of this framework: (1) the adaptive cycle which defines the system response to disturbance; (2) socio-ecological systems as linked socio-economic and biophysical systems; (3) the nesting of adaptive cycles to link systems operating at different spatial and time scales; (4) the definition of failure pathways that can lead to system collapse; (5) the identification of critical variables and their thresholds leading to collapse; (6) the management interventions to address failure pathways; and (7) the sustainability strategy as a combination of interventions to achieve sustainable outcomes.

2.1. The Adaptive Cycle

The adaptive cycle describes how an ecological or social system can be sustained in obtaining resources for its survival, and its ability to accommodate disturbance and recover (Gunderson and Holling (2002)). There are four phases: (1) Exploitation – the use or harvesting of resources; (2) Accumulation – the storage of material or energy in the system; (3) Release – the disturbance of the system; (4) Reorganisation – restructuring of the system after disturbance (Figure 3).

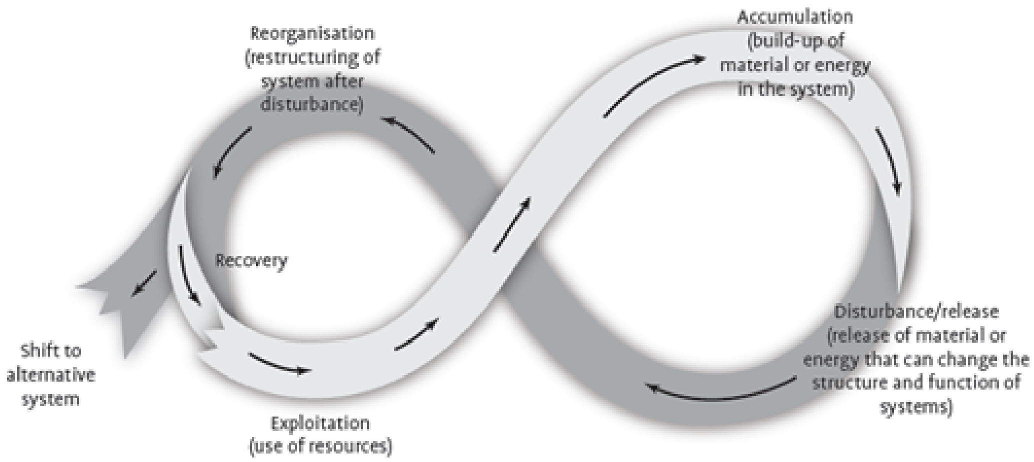

Figure 3. The Adaptive Cycle (adapted from Gunderson and Holling (2002))

The adaptive cycle can be sustained if the resources continue to be available and the system can recover from disturbance. Otherwise, the system may shift to an alternative (degraded) system.

2.2. Socio-Ecological Systems

Socio-ecological systems are linked socio-economic and biophysical systems. This highlights four generic sustainability issues: (1) the capacity of a natural system to be sustained; (2) the impact of human activity on the natural system; (3) the contribution of natural systems to human activity; and (4) the capacity of the socio-economic system to be sustained (labelled 1 to 4 in Figure 4). In this context, impact assessment of proposed developments is one component of Issue 2 (the link from human activity to the natural environment). Ecosystem services are a positive expression of Issue 3 (link from biophysical systems to socio-economic systems) while environmental disasters (like flooding and hurricanes) are an example of a negative impact on socio-economic systems of Issue 3. Ecosystem management relates to Issue 1 (sustainable biophysical systems), while institutional analysis is an example of Issue 4 (sustainable socio-economic systems).

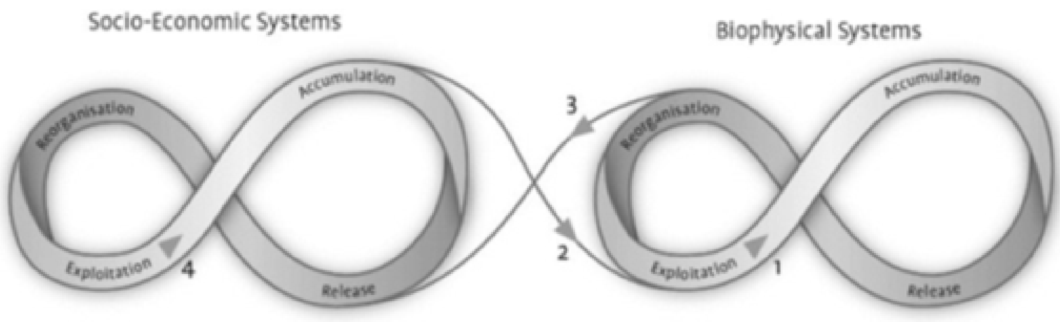

Figure 4. Socio-ecological Systems (Jenkins (2016))

2.3. Nested Adaptive Systems

Sustainable management issues often involve multiple spatial and time scales that are linked, i.e. nested systems. Figure 5 shows the example of relationship between nutrient contamination of a catchment and its linkages to algal blooms in a streambed.

The catchment adaptive cycle is (1) exploitation – nutrient intensive farms; (2) accumulation – the cumulative load of nutrient sources; (3) release – the discharge of nutrients into surface runoff and groundwater seepage; (4) recovery – nutrient attenuation. This is linked to the streambed adaptive cycle through the nutrient load to the stream with (5) exploitation - periphyton growth associated with nutrients, light and temperature; (6) accumulation – the build-up of periphyton cover on the streambed; (7) disturbance – the occurrence of algal blooms; and (8) recovery – algal removal by flushing flows or invertebrate grazing; or (9) ongoing algal blooms.

2.4. Failure Pathways and Critical Variables

The nested adaptive cycles for algal blooms in rivers is an example of a failure pathway. This example was drawn from a sustainability analysis of water management in Canterbury (Jenkins (2018)) where some rivers are experiencing an increasing frequency of algal blooms in catchments undergoing land use intensification. Bacterial contamination and sedimentation are two other forms of streambed degradation in Canterbury rivers.

Analysis of the system is needed to find out what is driving the degradation. An analysis of six New Zealand lakes experiencing eutrophication indicated that each lake had a different failure pathway leading to eutrophication (Jenkins (2016)).

For the failure pathway it is necessary to identify the critical variable to be managed to achieve sustainable outcomes. Table 1 sets out the critical variables for algal blooms in Canterbury rivers. Examples are the nutrient loss rates associated with nutrient intensive farming, and the accrual period between flushing flows with respect to the build-up of periphyton in rivers.

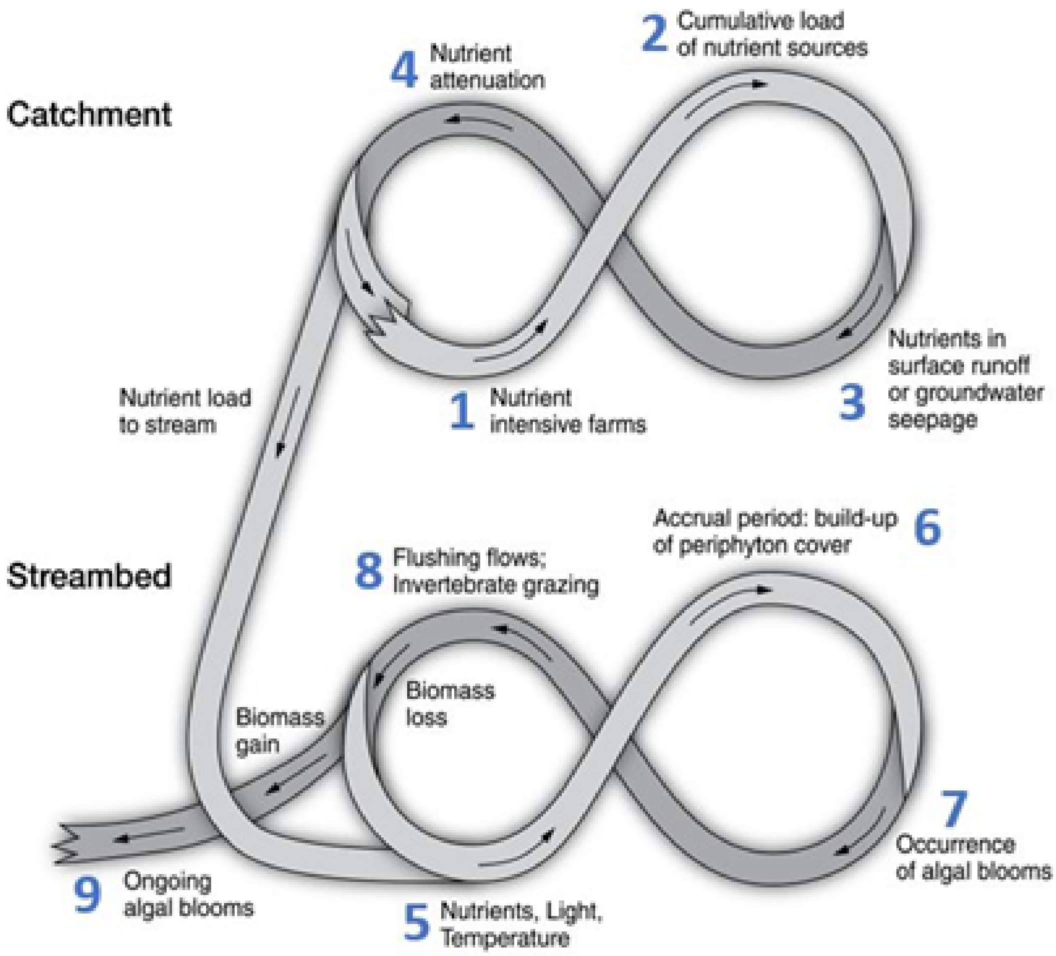

Figure 5. Nested Adaptive Cycles for Algal Blooms in Rivers (Jenkins (2018))

2.5. Management Interventions

Management interventions in the biophysical system can be developed for each phase of the adaptive cycle. These have been derived from the stewardship strategies of Chapin et al. (2009): (1) reducing the pressure on the resource in the exploitation phase; (2) addressing legacy issues of accumulated changes in the past in the accumulation phase; (3) increasing the resilience of the system in the disturbance/release phase; and (4) rehabilitating the adverse effects of the system for the reorganisation phase (Figure 6).

Management interventions for algal blooms in rivers are set out in Table 2. Note the suite of interventions involve actions by many parties, e.g. farm practices adopted by farmers, catchment limits and environmental flows set by the regional council, and, public health warnings given by the Health Department. This requires new institutional arrangements to ensure coordination of the suite of interventions as part of the sustainability strategy.

Table 1. Critical Variables for Algal Blooms in Rivers (Jenkins (2018))

Adaptive Cycle Phases	Critical Variables
Catchment exploitation Nutrient intensive farms	Nutrient loss rates
Catchment accumulation Cumulative load	Catchment contaminant load
Catchment disturbance Contamination of surface runoff and groundwater	Nutrient concentration in runoff and seepage
Catchment reorganisation Nutrient attenuation	Nutrient attenuation factors
Streambed exploitation River contamination	Nutrient, light and temperature levels
Streambed accumulation Build-up of periphyton	Accrual period between flushing flows
Streambed disturbance Potential for algal blooms	Periphyton cover Chlorophyll a level
Streambed reorganisation Recovery from algal blooms	Flushing flows Invertebrate grazing

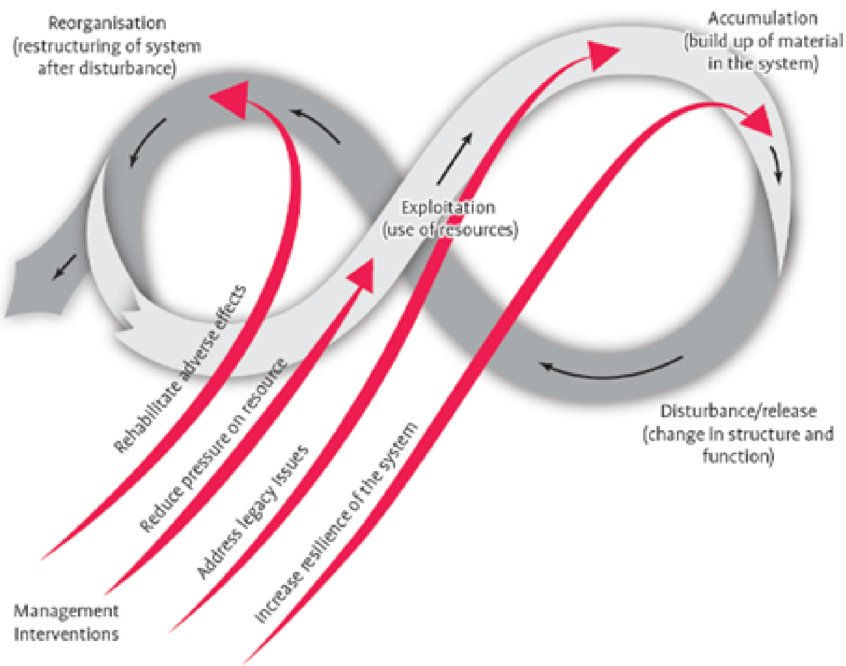

Figure 6. Management Interventions for each Phase of the Adaptive Cycle (Jenkins (2016))

Table 2. Interventions for Algal Blooms in Rivers (Jenkins (2018))

Adaptive Cycle Phases	Interventions
Catchment exploitation Nutrient intensive farms	Improved farm practices to reduce loss rates
Catchment accumulation Cumulative load	Catchment limit on contaminant load
Catchment disturbance Contamination of surface runoff and groundwater	Riparian planting Woodchip bioreactors
Catchment reorganisation Nutrient attenuation	Constructed wetlands
Streambed exploitation River contamination	Concentration limits for nutrients Streambed shading
Streambed accumulation Build-up of periphyton	Maintenance of flushing flows
Streambed disturbance Potential for algal blooms	Public health warnings
Streambed reorganisation Recovery from algal blooms	Sediment removal to increase invertebrate habitat

2.6. Institutional Arrangements for Interventions

An adaptive cycle can be described for the process of developing management interventions to achieve sustainability (Figure 7). The four phases are: (1) the use of human and economic resources to address a sustainability issue (exploitation phase); (2) the accumulation of knowledge, social, cultural and economic capital to develop sustainability strategies (accumulation phase); (3) the formulation of new approaches that change existing practices (disturbance phase); and, (4) the development of new approaches to implement the new approaches (reorganisation phase). This has the potential to lead to the adoption of management interventions to achieve sustainability. However, the failure to develop adequate actions will lead to ongoing degradation.

The management interventions for the biophysical system (Figure 6) can be linked to the institutional arrangements from the socio-economic system (Figure 7) to show an overall framework for the development of sustainability strategies (Figure 8).

2.7. Nested Adaptive Systems Analysis as a Sustainability Transition Approach

Loorbach describes three prominent approaches to sustainability transitions research: socio-ecological, socio-technical and socio-institutional (Loorbach et al. (2017)). The socio-ecological approach considers coupled ecological and social systems, and, system resilience to disturbance. The nested adaptive systems analysis of this paper, particularly the first five elements, follows a socio-ecological approach. The socio-technical approach focuses on dominant technologies that are the subject of transitions. Typical examples are systems in which infrastructure and technologies play an important role, such as energy, transport and water. The socio-technical approach is relevant to the sixth element of the analysis in this paper in defining potential management interventions. The socio-institutional approach focuses on the institutional cultures, structures and regimes in which transitional change takes place. Attention is given to the role of

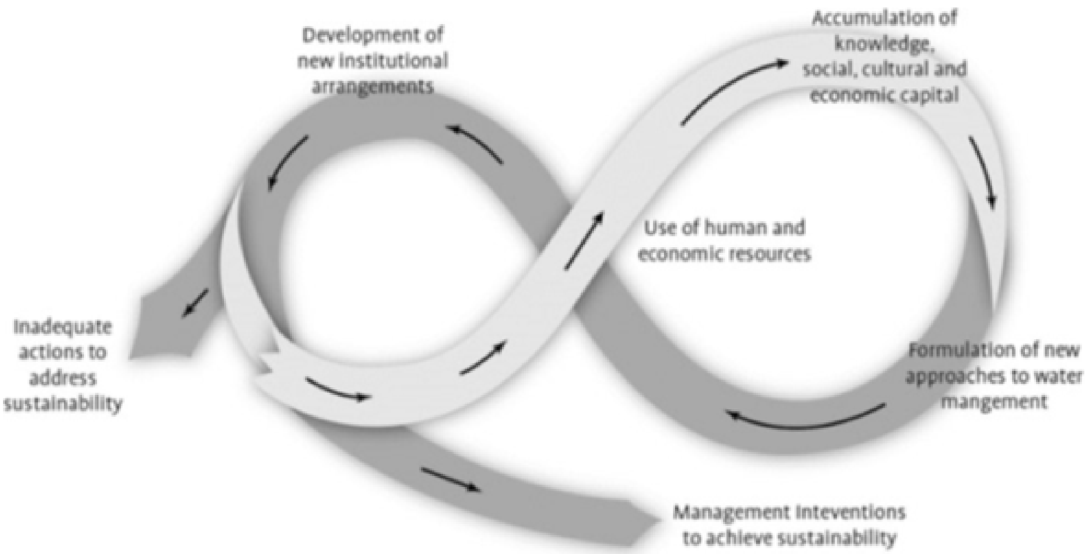

Figure 7. Adaptive Cycle for Institutional Arrangements (Jenkins (2016))

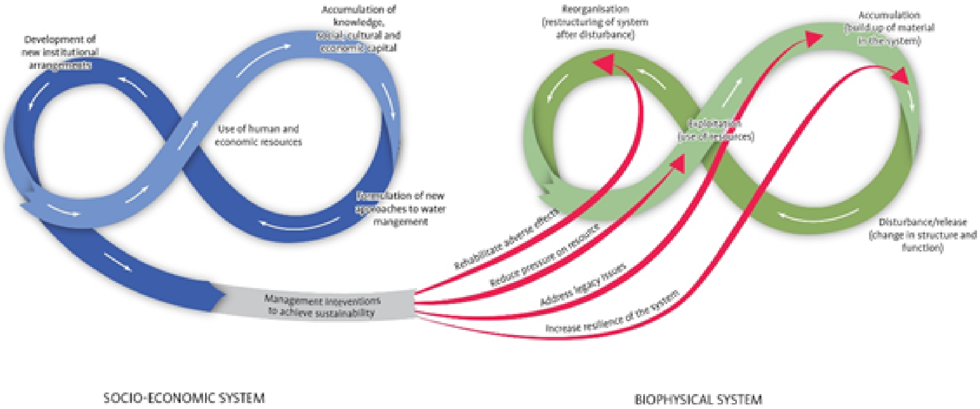

Figure 8. Framework for Developing Sustainability Strategies (Jenkins (2016))

agency and governance in transitions. The socio-institutional approach is relevant to the seventh element of the nested adaptive systems analysis relating to the process of generating the management interventions and the institutional arrangements for their implementation.

3. Sustainability Strategies in Practice

Several examples of the application of this systems approach to achieve sustainable outcomes are set out below. The crucial components in practice are: (1) the analysis of the biophysical system to identify failure pathways and critical variables, (2) the outcomes that were sought, (3) the suite of actions (i.e. management interventions) undertaken, and (4) the institutional arrangements for developing and implementing the interventions including the incentives for existing users to take action.

3.1. Case study of the Pahau Catchment

One of the initial applications of sustainability strategies in Canterbury was in the Pahau Catchment, a tributary of the Hurunui River. An investigation of the cause of algal blooms in the Hurunui River identified that the Pahau Catchment was the greatest contributor of nutrients to the river. The Pahau Catchment was the dominant failure pathway and nutrient loads were the critical variables. The outcome sought was the reduction of nutrient load.

The institutional arrangement was a community/government partnership which was formed to investigate issues, involve the community and implement improvements (Jenkins (2009b)). Actions agreed to by the community included controlling stock access to waterways and land use improvements by farmers, riparian plantings by landholders along river reaches, and, irrigation management improvements by the irrigation company. The regional council facilitated the process and provided extension advice. It also undertook water quality monitoring. The voluntary actions by the community led to a 60% drop in phosphorus load over 5 years (Figure 9). No statutory mechanisms were involved. The incentive for farmers to take action was that they did not wish to be seen as the "pariahs in the community" causing algal blooms for people downstream.

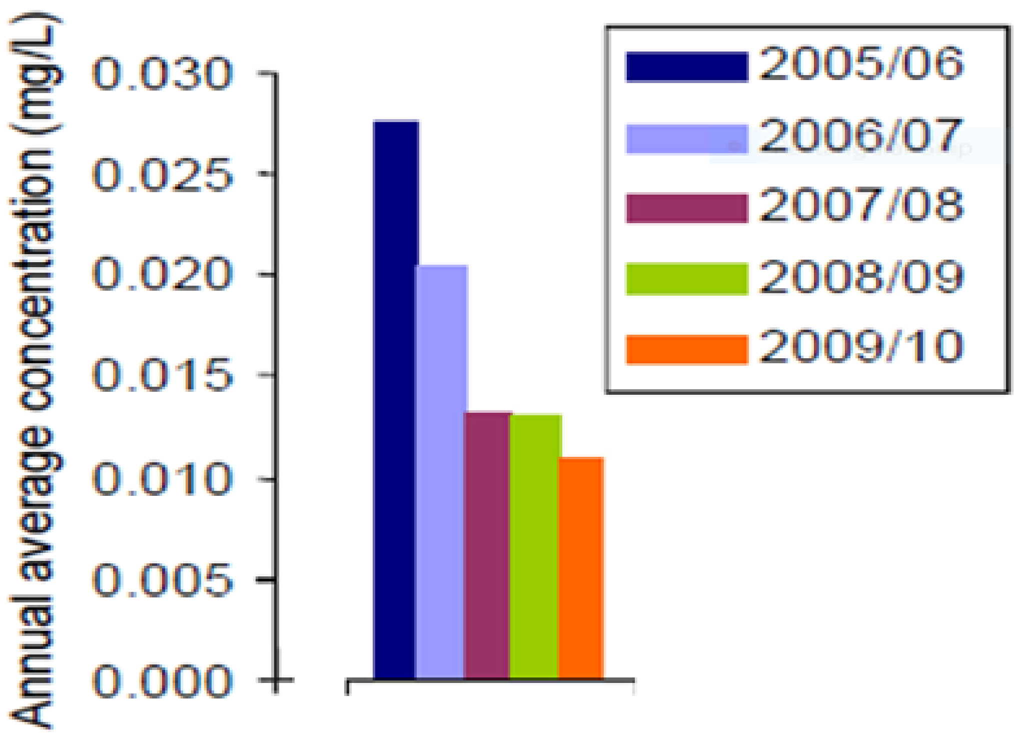

Figure 9. Reduction in annual average phosphorus concentration in the Pahau River (Jenkins (2018))

3.2. Canterbury Water Management Strategy

The success of this approach and other small-scale examples in Canterbury led to the development of a water management strategy being undertaken for the entire region based on nested adaptive systems with governance by self-managed communities (Canterbury Water (2009); Jenkins (2018)). Rapid expansion of irrigation for the conversion of dryland farms to dairying led to water availability limits being reached for surface water and groundwater. Initial strategic investigations focused on providing storage on Canterbury's alpine rivers which account for 88% of the annual average surface water flow (Morgan et al. (2002); Aqualinc Research Limited (2008)).

However, there were community concerns not only with the reduction in flows in rivers and decline in groundwater levels from increased irrigation withdrawals, but also with the impacts on water quality from land use intensification. Nitrate and bacterial contamination of groundwater was increasing and exceeded drinking water standards in some locations (Hansen and Abraham (2009)). Nutrient enrichment, algal blooms, faecal contamination, siltation and nitrate toxicity were approaching, and in many cases exceeding, water quality standards in the lower reaches of foothill and alpine rivers, and in groundwater-fed lowland streams (Stevenson et al. (2010); Robinson and Bolton-Ritchie (2014)).

Furthermore, there were concerns about storage on the main stems of alpine rivers including (1) impacts on landscape and ecosystem habitat, (2) flood-flow reduction reducing the number of braids in braided rivers, (3) sediment entrapment reducing bedload downstream and sediment supply to the coast leading to increased coastal erosion, (4) reduced flushing flows resulting in increased frequency and persistence of algal blooms, (5) temperature stratification in reservoirs leading to deoxygenation of bottom waters, (6) nutrient retention in reservoirs leading to aquatic weed infestations, and (7) reduced instream recreational opportunities for whitewater sports and fishing (Jenkins (2007b)).

The impact assessment process under the Resource Management Act failed to adequately address these concerns. While the purpose of the Act is "sustainable management", i.e. allowing the use of resources subject to maintaining environmental bottom lines, there is no elaboration in the Act on how decision makers can apply this purpose. Interpretations by the courts have defined an "overall broad judgement" of balancing resource use and environmental effects (Skelton and Memon (2002)). This interpretation has led to the Environment Court and hearing commissioners to approve further intensification despite limitations on water availability and degraded water quality (Environment Court (2005), Milne et al. (2010)). In addition, with the Environment Court able to review the technical merit of decisions, resource management was a highly legalistic process and resulted in an adversarial style of decision making.

Focusing on storage as a method of addressing water availability issues did not have widespread community support. The impact assessment process which was designed for individual projects was inadequate to address the cumulative effects of multiple projects, and its adversarial nature exacerbated community conflict. A paradigm shift in water management in Canterbury was needed. There was a need for an approach which (1) addressed the sustainability limits of water availability, (2) managed the cumulative effects of water extraction and land use intensification, and (3) facilitated consideration of multiple interests at multiple spatial scales.

The regional council introduced a strategic approach based on nested adaptive systems (Gunderson and Holling (2002)) and collaborative governance (Ostrom (1990)). The Canterbury Water Management Strategy (CWMS) was developed through a multi-stakeholder steering group under the auspices of the Canterbury Mayoral Forum, and with extensive community involvement in the process (Canterbury Water (2009)).

Four spatial scales were considered with different issues relevant to the different scales: (1) the regional scale to address water availability and land use intensification; (2) the catchment scale to address sustainability limits of water use, cumulative impacts of intensification, and reliability of supply for irrigators; (3) the subcatchment level to address environmental flow requirements in river reaches, and ecosystem management of streams and their riparian margins; and (4) the property level to address land use practices that influence water quantity and quality (Jenkins (2007a)).

Of Ostrom's characteristics for institutions for sustainable management, the collective choice arrangements were a key element of the CWMS. This included (1) stakeholder and community engagement in developing strategic options and fundamental principles for the strategy; (2) definition of strategic options by the multi-stakeholder group; (3) region-wide consultation with the community on option preferences; (4) strategic investigations of likely outcomes to inform the engagement process; (5) sustainability appraisal of the options in relation to economic, social, cultural and environmental criteria; (6) the agreement on a strategic approach to water management, environmental restoration, infrastructure requirements, and governance arrangements (Jenkins and Henley (2014)).

Rather than just addressing the contentious outcome of increased water availability for proponents of further irrigation, there was widespread support for integrated water management that addressed ten community-determined priority outcomes for water: ecosystem health, natural character, kaitiakitanga (Māori stewardship), drinking water, recreation, water use efficiency, irrigated land area, energy, economy, and environmental limits.

The formulation of the strategic options and the implementation of the agreed strategy followed the process of 'Strategic Choice' (Friend and Hickling (2005); Jenkins (2018)). The strategic discussions started with two opposing options: (1) storage on the mainstems of alpine rivers, and (2) a moratorium on further water resources development until environmental issues were resolved. Another option emerged which incorporated improved water use efficiency (to facilitate greater water availability without storage), and improved land use practices (in relation to their effects on water quality) by existing users, and, different lower impact forms of storage (e.g. off river storage and managed aquifer recharge) rather than dams on the main stems of alpine rivers.

The implementation of the agreed strategy contained three key components: (1) immediate actions, e.g. the establishment of nutrient limits and biodiversity improvement projects; (2) investigations to deal with important areas of uncertainty, e.g. setting catchment load limits and land use practice improvements; (3) definition of the way that deferred choices would be made, e.g. the continuation of the collaborative approach, at the local level through ten Zone Management Committees and at the regional level through a Regional Water Management Committee with the development of zone and regional implementation programmes.

The implementation and operational processes led to new institutional arrangements. Zone Committees were established including the authorities for water management (regional council) and land use (city and district councils), rūnunga (Māori tribal groupings), and six to seven appointed members of the community. The purpose of Zone Committees is to facilitate community engagement in developing Zone Implementation Programmes (ZIPs) to achieve the ten community outcomes of the CWMS at the Zone level. The ten zones are shown in Figure 10. The Regional Committee has regional council, city and district council, Māori, community members, and a representative from each Zone Committee. It is nested rather than a hierarchical arrangement: Zone Committees deal with catchment issues and Regional Committee with regional issues.

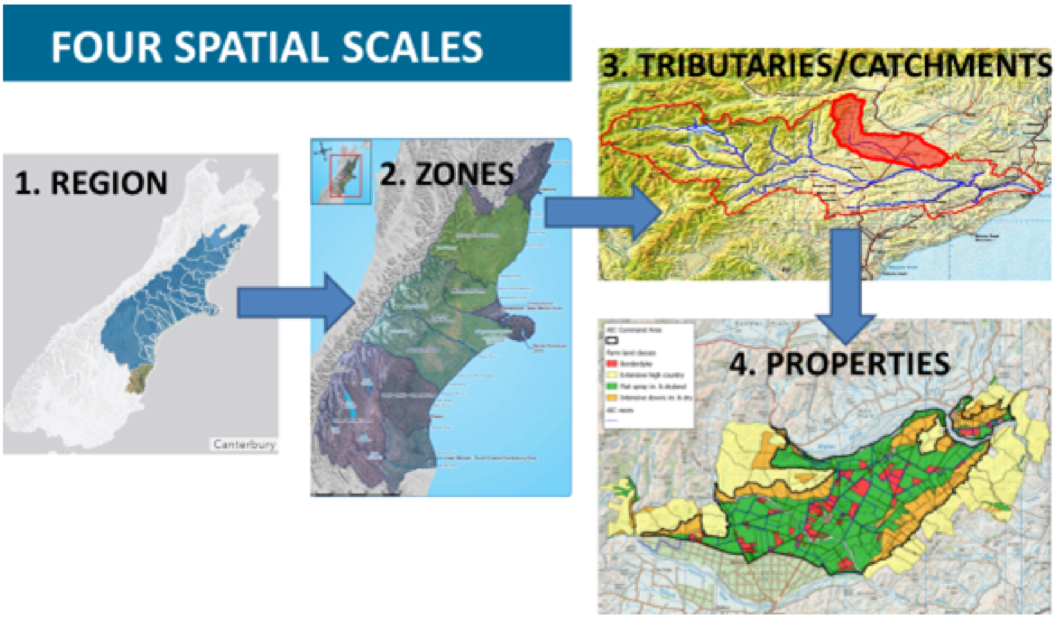

Figure 10. Four spatial scales for implementing the Canterbury Water Management Strategy (Jenkins (2017))

Operational management has introduced an alternative to the RMA of the regulator setting consent conditions that are inspected for compliance by the regulator. This alternative reflects Ostrom's principles for self-governing communities. The primary governance element is the establishment of farmer collectives based on irrigation districts or tributary catchments, with a secondary governance element at the farm property (Figure 10). It is a nested system based on achieving water quality outcomes in rivers and lakes which lead to contaminant load limits defined as a collective responsibility; and, with each farmer developing a farm management plan to specify on-farm actions to meet farm management objectives within an environment management system for the collective. Each farmer is responsible for monitoring the actions undertaken and achievement of targets which are audited by a certified farm auditor.

Substantial progress has been achieved. Water use efficiency has improved, primarily through conversion of border dyke (flood) irrigation to spray irrigation (Brown (2016)). Catchment nutrient load limits have been set and land use management practices are changing to reduce nutrients in runoff and groundwater seepage. Environmental flows have been increased for some rivers. Priority areas for rehabilitation have been identified and enhancement projects undertaken (Environment Canterbury (2016)). Māori involvement in water governance and management has increased.

While there have been significant positive changes toward sustainable water management, a sustainability analysis identified shortcomings in the level of intervention in the implementation programmes and issues that have been inadequately addressed (Jenkins (2018)). One implementation constraint is the affordability of management measures. Affordability has been an issue in finding viable storage schemes to improve water availability, for improvements in land management practices to reduce water quality contamination, and for communities in increasing drinking water treatment for addressing the risks of waterborne diseases. There is a related issue for institutional arrangements and funding mechanisms for water infrastructure. While the private sector can address commercial water resources development it is not well placed to address lake or river restoration, climate change strategies, managed aquifer recharge, biodiversity projects and catchment-wide public good infrastructure. Furthermore, in New Zealand there is no central government agency for water management, and regional councils have been established with a regulatory function.

3.3. Christchurch Airshed Strategy

Investigations into the causes of air pollution in the Christchurch Airshed indicated that wood-fired residential heaters contribute about 90% of the emissions to the high particulate pollution events in Christchurch that occur during inversion conditions. To achieve the particulate standard of 50 ug/m^3 (24-hour PM_{10}) (New Zealand Government (2004)), there was a need to reduce overall particulate emissions from 11.4 to 3 tonnes per day and home heating emissions from 9.5 to 1.4 tonnes per day. This meant removing 35,000 open fires and high emission burners from the airshed.

A regulatory regime was put in place to prohibit solid fuel burners in new homes (from 1 January 2003), prohibit open fires (from 1 January 2006) and high emission burners (from I January 2008 or 15 years after the date of installation) (Environment Canterbury (2011)). This regulatory regime was insufficient to achieve the air quality standard because of the large number of existing wood heaters in Christchurch.

An incentive scheme was established – the Clean Heat programme – to encourage existing owners of wood heaters to convert to heat pumps. The initial programme was only achieving 1,000 conversions per year. A major review was undertaken based on the motivational model of Lawler and Porter (1967). This included: (1) improving the value of air pollution reduction to the cost of conversion by increasing the subsidy to reduce the conversion cost, (2) increasing the public recognition that wood heaters were the prime contributor to air quality impairment through a social marketing campaign, (3) improving people's understanding of what needs to be done to change from a high emission wood heater by having assessors who would inspect homeowner's needs as part of the Clean Heat programme, and (4) providing people with project management assistance to implement the conversion (Jenkins (2005)). This revised programme (Environment Canterbury (2010)) increased the conversion rate to over 3,000 conversions per year.

Figure 11 shows the improvement in air quality with the second highest measured annual value falling from 179 ug/m^3 to 84 ug/m^3.[1] The funding for the Clean Heat programme was achieved through a targeted rate on the ratepayers living in the Christchurch airshed (i.e. the beneficiaries of the programme).

4. Evolution or Revolution

The changes needed to develop sustainability strategies to address situations where environmental limits have been exceeded require a revolution in impact assessment rather than an evolution. Some of the key differences are: (1) a focus on outcomes rather than a focus on effects; (2) a framework based on systems analysis rather than impact assessment; (3) strategy-led development rather than proponent-led development; (4) consideration of all users not just proposed actions; (5) consideration of

[1]The programme was interrupted by the Christchurch earthquakes

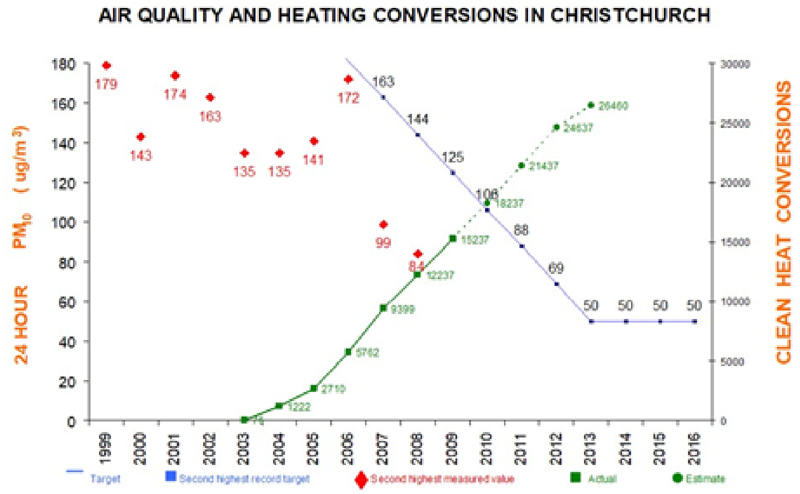

Figure 11. Improvement in Air Quality in Christchurch (Jenkins (2009a))

incentives not just regulation; (6) monitoring and management of aggregate and individual outcomes rather than monitoring compliance with conditions; (7) redesign of institutional arrangements rather than reliance on existing institutional arrangements; and, (8) need for a financial mechanism for implementation rather than relying on the proponents bearing the cost.

[1] The programme was interrupted by the Christchurch earthquakes

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