Complex responses for complex systems: Insights from the Southern African Millennium Ecosystem Assessment (SAfMA)

E. Bohensky[1], T. Lynam and R. Biggs

Abstract

Ecosystem services are embedded in complex, coupled systems of people and nature, known as social-ecological systems. The complexity of these systems stems from their non-linearity, discontinuities across space and time, and ability to surprise, making it difficult to design and implement effective responses when systems fail to deliver vital ecosystem services to people. This complexity also presents a challenge to assessing the effectiveness of responses. We present a model that illustrates how each ecosystem service-related problem and its set of possible response options are defined by the extent of congruence of three scopes: the scope of awareness of the problem, the scope of its impact, and the scope of the power or influence to respond. Drawing from the Southern African Millennium Ecosystem Assessment (SAfMA) experience of identifying and assessing responses, we explore the applicability of this model to several cases in southern Africa, where several unprecedented as well as conventional types of responses are taking place with varying degrees of success. These are reviewed in light of existing theory about complex social-ecological systems and the characteristics that lead responses to succeed or fail. We conclude by highlighting insights from SAfMA that may lead to the design and implementation of more effective responses in the future.

Introduction

Despite commitments at many levels and scales of society to solve problems such as biodiversity loss, poverty, and corruption, these problems show remarkable persistence. Even in situations such as that of global poverty, where resources are available for an apparent solution, the problem remains as persistent as ever. This is not for lack of trying. In fact, the disturbingly long list of failed development projects and policy initiatives suggests that a minority of social and ecological problems are successfully resolved. Why is it that human responses to problem situations do not always result in sustainable solutions? In this paper we present an explanatory model of why failure so often occurs from our experiences of exploring response options within the context of the Southern African Millennium Ecosystem Assessment (SAfMA), part of a global initiative to evaluate the relationship between ecosystem services and human well-being at multiple scales, including the options available for intervening in ecosystems to improve service delivery. We then suggest simple guidelines for designing responses that work.

Why we don't always get it right

Ecosystem services and the people who use and manage them are part of complex systems which comprise coupled social and ecological systems[2]. Complex systems are

[1] Corresponding author. Centre for Environmental Studies, Geography Building Room 2-1, University of Pretoria, Pretoria 0002 South Africa Tel (+27) 21-8082604. erin@sun.ac.za.

[2] These are systems in which humans and ecosystems are coupled to varying extents and intensities. These couplings mean that there are feedbacks (positive and negative) that are stimulated in one part of the system (social or ecological) by changes in another part of the system. Thus for example, a drought might reduce the

inherently unpredictable. They respond in surprising ways. They are adaptive in that people and ecosystems adapt reactively (to what is experienced or conceived) and proactively (to what may still happen). People change their purchasing behaviour when prices or incomes change or when they anticipate an inflationary increase. Vegetation communities change structure and composition when the hydrological regime changes. Given the adaptive capabilities and inter-connectivity of complex systems it is seldom if ever possible to have sufficient knowledge about the structure or functioning of any complex system to reliably predict the outcome of an intervention or response. All responses are therefore experimental.

The Millennium Ecosystem Assessment (MA) defines responses as "human actions, including policies, strategies and interventions, to address specific issues, needs or problems in different domains." Assessing responses is one of the most challenging, but critical, aspects of the MA. At the global scale, response typologies have been identified, examples reviewed, and decision analytical frameworks proposed. Within SAfMA, approaches spanned a range of methodologies, which at coarser scales (regional and basin) consisted of reviewing past and existing responses, and at local scales tended toward interactive processes with stakeholders to elicit information about coping strategies used or likely responses under different scenarios. Despite the wealth of responses "out there" to learn from, and contrary to our expectations, we encountered great difficulty in trying to distill clear message about what works and what does not from the available material.

In scrutinizing our SAfMA experiences, we observed that it is difficult to assess responses in complex systems for the same reasons that it is difficult to effectively respond. These relate to the properties of complex systems and the ways in which they are dealt with by people. We discuss four properties that lead to some of the most profound challenges we face.

Simplification. Human instinct, when confronted with complexity, is to simplify. Complex social-ecological systems are coupled. Whether we are scientists, managers, or decision-makers, we tend to simplify the complexity of these systems by breaking them systems down – by uncoupling their components - but fail to put the pieces back together again. This is evident in the historical tradition throughout most of the world of a sectoral approach to resource management, in which maximizing gains from individual services has been paramount. In our attempts to assess responses, we too are guilty of such simplifications: we "typologize" and categorize our responses according to ecosystem service and nature of response.

Scale lags. Complex adaptive systems are discontinuous in space and time: they may be patchy, or "lumpy", change episodically, and have alternative states. Ecosystems themselves are "moving targets" (Redman and Kinzig 2003) but their processes have characteristic scales at which they operate. Management processes, however, typically occur at social or political levels of organization - nation, province or district - and are often correlated with time-scales of social or political significance, and these, too, can and do change. The implication is a mismatch between ecosystem processes and management. Such spatial lags are clearly observable in the design of protected areas that truncate ecosystems at national borders. The temporal equivalent is a response that is too slow or too quick (or more often, too short-term) to appropriately deal with the process. Within the spatial and temporal lag that separates each

food and money available to a rural household thus reducing the amount they can spend on nutrient inputs the following season. This reduces next season's yields and further reduces household economic viability.

problem and a response to it, multiple problems and responses are likely to have also occurred and interact with those problems and responses of particular interest. This complicates the task of assessing responses, because the problem that a given response was intended to solve may not be clear to the assessors.

Limits to knowledge and understanding. Mental models are influenced by a wide range of belief systems, available information, and power structures. Interventions in complex systems are often biased by prevailing (usually incomplete) mental models or behaviors, which typically belong to the people or groups with the greatest influence. Because certain mental models dominate, interventions are made that are not representative of everyone's mental models, and therefore not beneficial to everyone. Apart from this, we don't fully understand complex systems, nor can we predict their future trajectories. The implications and consequences of using uncertain, incorrect, or biased information can be severe. In assessing responses, we too have mental models and biases that shape the conclusions we make.

Trade-offs. The need to make trade-offs between ecosystem services, or between ecosystem services and other social or economic benefits, or between social groups is an inherent feature of complex systems, and will usually intensify in situations of increased competition for services. Trade-offs and their consequences for alternative options not chosen are often poorly understood. Any framework or systematic approach to decision-making depends on the use of criteria that needs to be agreed upon by stakeholders. Making trade-offs may result in the process of simplification discussed above, in that the system is simplified through a choice made to derive benefits from one part of a system rather than other parts or the whole. The trade-offs problem is about making decisions between two or more things, which all have consequences for the others. As response assessors, we also may not be aware of the trade-offs associated with each response. We can propose decision-making frameworks to help identify and weigh the consequences of a response but these will necessarily represent a partial view of the problem. Ultimately, a decision must be made and evaluated based on someone's objectives.

Given the above, one might conclude that if we dealt with systems in their full complexity, at the appropriate spatial and temporal scales (whereby management or decision-making happens at the scale of the ecosystem process), and had better information at our disposal to form more complete, less biased, mental models, we'd be designing and implementing more effective responses. Trade-offs would remain inevitable, but at least we'd be better equipped to make them wisely and have a better sense of the implications of how each choice we make affects the options not chosen.

This is a logical conclusion, but in practice such opportunities are rare. That said, if we can identify patterns of success and failure in our current responses, this should guide us in developing effective responses to change in complex systems. We believe the model we introduce in the next section illustrates the process of response formulation in a complex system and therefore provides insight into what may make responses successful.

Impact, awareness, and power scopes: A model of the response process

Changes in some aspect of the world, be it an economic, a political or an ecological change, have an impact. There is a spatial area and temporal period over which the impacts are experienced. We call this spatial and temporal extent the *impact scope*. Climate change,

for example, has a global scope. All places on the earth are likely to be impacted. Not uniformly, not in the same way, but impacted.

Often because of time lags between the initiation of a change (such as climate change) and the experience of an impact, people or organisations may not be aware that they are in fact being impacted by the change. This lack of awareness may also be due to a lack of information or due to limited knowledge or understanding of how changes can result in impacts. For example, San people living in the Kalahari may not know that elevated CO_2 levels will result in higher vegetation growth rates if water is not limiting. We call this the *awareness scope* – the degree to which people are aware of the causes and impacts of a change.

Once people are aware of an impact, actual or pending, they can then respond. But their ability to respond is a function of the *power scope*; that is, the power or influence they have over the processes governing the change. It is also a function of their motivation or desire to use their power or influence to make this happen. This is where political and economic processes, if functioning effectively, come into play. Societal best interests are served by effective power structures that distribute power proportionately across those impacted. For any set of impacts there will be a diversity of responses. The political and economic distributive mechanisms will select the societal response and implement it. Our San community have little power or influence over the forces driving climate change and the power structures that be. The scope of their power or influence may comprise only their own community.

In summary, the process of response to a complex system is usually governed by the advent of an impact, the awareness of the impact and what can be done about it, and the power or influence to do something about it. The San community in our example may be impacted by climate change, and may be aware of some aspect of the impact – the higher vegetation growth rates, perhaps – but may not be aware of its cause, and have little power or influence over the impact. Thus, if they respond to the impact, their responses are likely to be simplified, due to their lack of awareness of the full complexity of the problem; lagged in space or time, and implemented only in their immediate space and some time after they first became aware of the impact; limited by knowledge, and as such may be driven by prevailing, incomplete mental models; and traded off with other responses, though they will be unaware of the consequences.

We hypothesise that the best circumstances for effective responses are those where the scope of the impacts, the scope of awareness, and the scope of power are at least congruent (Figure 1). It would be acceptable for the awareness scope to extend beyond the impact scope but the power scope should ideally remain congruent with the impact scope.

Let us firstly examine the concept of impact awareness. Awareness means that people within the impact scope of a change are aware of an impact. They may also be aware of a proposed response and its possible impacts. However, people are usually only partially aware of a change, its impacts, and proposed responses and their possible impacts. What this model assists us to recognise is that the provision of information, whilst an important contributor to expanding the scope of awareness is a necessary but not sufficient condition. We can never all we need to know; thus the scope of awareness can never match those of impact or power. It is therefore necessary to experiment and keep the power as close as possible to those with the information. The model also makes us recognise that in cross-scale processes and

structures awareness and power must be cross-scale i.e. the scopes will be distributed across scales both spatial and temporal.

This brings us to the issue of power or influence. People do not, as individuals, need to be able to directly influence a response. They do need mechanisms which enable them to express their values and beliefs. Economic mechanisms or political mechanisms are fine. If people are uncoupled from the powers that decide on responses then the model suggests it is highly unlikely that these responses will be successful.

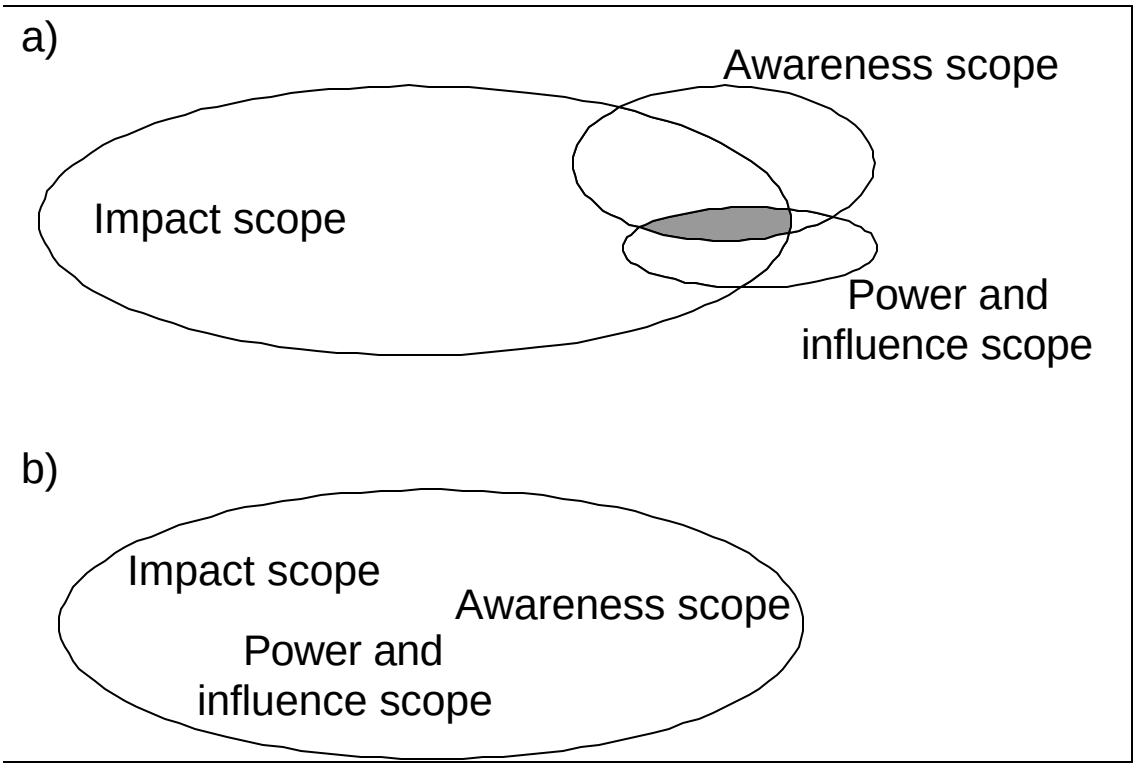

Figure 1. a) Impact, awareness and power scopes are incongruent. b) Impact, awareness and power scopes are congruent.

With the model we can explore some the problems noted previously that make it difficult to intervene effectively in complex systems and see what insights we can gain (Figure 2).

Simplification. Here an impact is sensed but not fully understood. In these situations the awareness scope is not congruent with the impact scope and sometimes not with the power scope. People's awareness is simplified to deal with the great complexity. Simplifications are important but the parts need to be put back together to make the awareness congruent.

Scale lags. Here all three scopes are incongruent, in space and/or time. The power scope needs to be lagged, spatially and temporally, to deal with lagged impacts. Awareness, if it keeps ahead in time of the impacts, provides the advantage of foresight.

Limits to knowledge and understanding. Incorrect models result in incongruent scopes of impact, awareness, and power. By enhancing efficient learning mechanisms, policy will

maximise increases in awareness and improved mental models. Furthermore, because we can't predict, there is a tendency to put the power where the information is. Instead, we should set the feedbacks to work at the appropriate levels, scales, or locations to bring impact, awareness, and power into congruence.

Trade-offs. Trade-offs may occur because people are unaware of the consequences of their decisions on other ecosystem services or other components of complex systems. In this case, the awareness scope has been simplified and therefore is not congruent with the impact scope nor the power scope. Trade-offs may also occur in spite of awareness of such consequences, but because the perceived benefits of making the trade-off outweigh the costs.

[INSERT FIGURE 2 HERE: Congruence of impact, awareness, and power scopes in situations of a) simplification; b) scale lags; c) limits to knowledge and understanding; d) trade-offs.]

Southern African responses to problems of ecosystem services and human well-being: failures looking for a place to happen?

In the southern African context, ecosystems and their services have been especially significant in the lives of the rural poor, although their benefits accrue to all members of the population. Historically, control over ecosystems and their services in the region was either poorly defined, communally governed, or dictated by the processes of colonization and apartheid in which control rested in the hands of a powerful minority. Today, significant change is occurring with respect to governance and ownership of and access to ecosystem services in southern Africa. These factors all add to the complexity and have posed particular challenges for designing effective responses.

A number of responses now being implemented in the region nonetheless demonstrate a cognisance of the problems noted above. This recognition has come about in part because of the novel opportunities of several national governments to draft new legislation since independence or a change in governance, and suggests an understanding of the flaws in some past policies. We are observing a departure from the sectoral approach to management of natural resources (as opposed to ecosystems) of the past, and the adoption of more integrated, sustainable, and equitable policies. The need to match scales of interventions to relevant ecological and social processes has also been recognized. This has been done through the transfer of rights to own, use or manage resources from the state to private entities, or to devolve or evolve management to more appropriate scales or organizational levels. Other responses are focused on expanding the knowledge base for decision-making by involving and providing access to information to stakeholders. This includes formal and informal education, public awareness campaigns, and increasingly making information available on the internet. Scenario planning exercises have been conducted in the region under the auspices of NGOs, private corporations, and multi-stakeholder associations, and while their objectives have varied, stimulating thinking about complex issues and building consensus are among the main reasons for using scenarios. The role of adaptive management is coming into the fore, with an emphasis on its principles promoted in the conservation and water sectors in South Africa. Adaptive management has long been a coping strategy of local people in the region, which continues to feature into their practice of livelihood diversification.

In what follows we review some responses that have been or are currently being used in the southern African region – many of them venturing into untested terrain - that address

these problems to varying degrees. We look at a range of interventions, past and present, at multiple spatial scales, and that are considered successes and failures. We interpret the example in the context of the model in each case.

Licensing ecosystem service use

Throughout much of southern Africa, woodfuel is an important ecosystem service that provides charcoal for heating and cooking. Local woodfuel depletion in some areas, however, is a serious concern. In the Gorongosa – Marromeu component of SAfMA (SAfMA-GM) the assessment of woodfuel as an ecosystem service indicated that the major drivers of the system (i.e. the system's governing structures and processes) were the following:

- Poverty. Many rural households had no other means of obtaining cash income. Urban households who purchased the charcoal sought the lowest cost energy option to satisfy their energy needs.
- Ambiguous property rights. The poorly specified property rights and limited ability or willingness of the government to enforce existing property rights meant that charcoal producers could use woodland resources from very large areas without paying for the resources.
- Transport networks. Production of charcoal was found along functional road transport routes.
- Lack of re-investment of resource rents in the management of the resource itself. Incomes generated from the woodland resources used were converted into consumption or urban wealth.
- Attitudes of Mozambican people to woodland resources. The woodland resources were seen as being almost inexhaustible and best used to produce income for the rural poor.

In an attempt to make the charcoal production system sustainable, the Provincial Government of Sofala has responded by trying to license the producers. This, however, does not address the broader system governing structures and processes (e.g. poverty and property rights). In a resource-poor environment poor people will easily find ways around the licensing and taxation. Urban people are not likely to be aware of the future impacts of current consumption rates nor of possible interventions that could make the system a sustainable income-generating and energy supply system. While there may well be an awareness of the different drivers as independent structures or processes, the solutions are not constructed to address the coupled system. The awareness scope is not congruent with the impact scope.

Policy mechanisms such as the issuance of licences to regulate ecosystem service use can function as simplifications that constrain the awareness and therefore the power and influence of the impacted group. In this case the Sofala government did not try to influence the indirect or ultimate drivers of fuelwood consumption, but rather its more proximate cause of woodfuel depletion, access to the resource.

Working for Water

Alien invasive plants are a significant problem in South Africa, with particularly negative impacts on water: they reduce approximately 7% of total streamflow (Versveld et al. 1998), consuming an amount of water on par with that used by the urban and industrial

sectors in major urban areas (Basson 1997). The Working for Water Programme in South Africa is an integrated multi-agency intervention to address the alien plant problem, and among the largest, most expensive of its kind. By hiring previously unemployed individuals to clear and eradicate invasive alien plants, Working for Water addresses the multiple objectives of ecosystem rehabilitation, water conservation, and poverty relief through job creation, as well as environmental education and awareness-raising about alien plants and water conservation. It is also encouraging the development of secondary industries to generate additional income and employment through the creation and marketing of products made from the cleared alien species.

In this example, a synergy is created between social development (job creation/poverty relief) and ecosystem conservation (alien eradication, restoration of hydrological flows, improved production potential of land). It capitalizes on complexity rather than simplifying it. The awareness scope has broadened: both the people employed by the programme and the many others who have learned about it due to its high visibility and public awareness campaigns now are familiar with the alien plant problem. There is at least some congruence of impact and awareness; the causes of alien plant invasions are complex, but to a large degree in South Africa the major driver is the production of pulp and timber with non-native species.

The power scope has not necessarily changed, as the Working for Water employees do not directly gain any power through this intervention (although they may indirectly by being employed), nor do those in higher levels of government relinquish any. This points to a potential drawback of the program: its high cost. Should funding for the initiative cease, there is unlikely to be further incentive for the work to continue, unless driven by bottom-up forces, such as revenues gained from the sale of alien plant products. Even so, this would be unlikely to allow the program to achieve and maintain operation at its current scale.

Creation of Catchment Management Agencies in South Africa

Following the nation's transition to democracy in 1994 and a new emphasis on ensuring equitable access to resources, the Water Act of 1998 mandated the establishment of nineteen catchment management agencies (CMA) to govern water resources in conjunction with local governing boards that represent a wide range of stakeholders. This decentralizes decision-making in the water sector, and while the national Department of Water Affairs and Forestry (DWAF) remains the custodian of South Africa's water resources and oversees its national strategy, the authority to execute the strategy will increasingly lie with the CMAs and their locally-elected governing boards. Each CMA is responsible for a water management area, for which it can license water users and establish charges for the provision of and different uses of water, the revenues from which will fund their management activities. It will also be responsible for implementing the appropriate resource protection measures in order to meet the requirements of the ecological reserve as mandated by law.

Although this is a promising response to the challenge of providing water to South Africa's under-serviced population and ensuring the needs of the environment, the existing backlog will in itself present a challenge, which will only be intensified by the likely increases in water use by the urban and industrial sectors. While the new arrangement allows management to occur at a scale more appropriate to ecosystem functioning, it is unclear if the CMAs, which are to be fully functioning in the next five to ten years, will have the capacity within these institutional arrangements to successfully implement the Act. Of concern is that

they are being charged with both the allocation of water and protection of the resource in their catchment, two not necessarily compatible tasks that were never before administered by a single authority (Rogers et al. 2000).

The three scopes of impact, awareness, and power would ideally be brought into congruence if the CMAs are able to govern effectively. However, a potential problem lies in the spatial configuration of the hydrological system, whereby some CMAs will be managing catchments that impact on (i.e. are upstream of) other CMAs. In essence, the scope of the impact will inevitably extend beyond the power scope, hence all CMAs must govern responsibly for all to benefit from the arrangement.

Evolution of management to supra-national scales

At the same time that management of some ecosystem services is being devolved to lower levels, it is also evolving to deal with large processes with many stakeholders. Large-scale problems such as regional water scarcity and conservation of large ecosystems require large-scale management structures. International water co-management organizations, such as the Orange-Senqu River Commission (ORASECOM) recently established by South Africa, Lesotho, Botswana, and Namibia, are designed to share the management of riparian resources in the Gariep and Senqu River systems and ensure water security for all members, on the premise that political instability in one state negatively affects others. In reality, power among stakeholders is likely to be uneven (Turton 2003). Currently, about five international water-sharing agreements and studies, in various stages of implementation, concern the Gariep River alone (DWAF 2002a). Cooperation in terms of water sharing is the jurisdiction of the SADC Protocol on Shared Water Courses, coordinated by the SADC Water Sector based in Lesotho.

In the conservation arena, transboundary or transfrontier conservation areas (TFCAs) cross international boundaries and are managed jointly by the participating nations. Several such areas either exist or have been proposed in the SAfMA region, though the role these areas play in conservation and development is still unclear and care must be exercised in their future development as it could potentially exacerbate previous *ad hoc* land allocation practices (ref.).

Devolution and evolution of authority to different scales does not always result in better management. In the case of CMAs, their power is constrained to their catchment, but impacts may be from outside/upstream. At the supra-national scale, there is no guarantee of adherence to principles of SADC treaties that are not embedded in national laws (SARDC 2001), which are likely to differ, sometimes irreconcilably, between members. There also may be too many members for any one to assume accountability. Furthermore, some impacts are likely to be beyond the regional power scope (i.e. world markets, tourism, climate change).

Privatization of conservation

Food production and biodiversity conservation have clashed particularly dramatically in southern Africa, where the need to feed a growing a largely impoverished, undernourished population has more often than not resounded more urgently than pleas to conserve biodiversity. Food production occurs in many forms, however, and while some, such as intensive cultivation, transform ecosystems, others, such as low-intensity grazing, have much

more modest impacts on ecosystems (ref.). The challenge in those areas best suited to the latter form is to make it biodiversity conservation economically viable.

The privitazation of conservation in several southern African countries began in the early 1980s, sufficiently long enough to serve as an experiment by which we can now compare outcomes across countries. In 1980, about 5% of South Africa's surface area was protected; the figure is 14% today and increasing (WDPA 2003). Protected area has also increased in Namibia and Zimbabwe. During that time, changes in wildlife protection legislation allowed a shift in ownership to occur. In South Africa, this resulted in a conversion from cattle and sheep farming to game farming, which was more profitable and enable the conservation of indigenous wildlife, initially through the lucrative trophy-hunting market and later to nature-based tourism.

The CAMPFIRE programme in Zimbabwe was launched in communal areas on the periphery of national parks or game hunting areas where cultivation and livestock ranching were coming into conflict with wildlife. Here, sustainable community-managed use of wild life, mainly through trophy hunting, was able to generate more income than the other major forms of livelihood, which was then distributed among community members. The model was not only implemented in Zimbabwe, nor was it limited to wildlife.

Against the more recent backdrop of political turmoil in Zimbabwe, however, CAMPFIRE has now become an example of how success turns into failure, with the state repossessing the areas given to individuals for itself. Transferring rights to own and manage services to private individuals gives them a stake in conserving those services, but these can backfire without adequate levels of institutional support.

Such interventions are aimed at achieving congruence between the power and impact scopes, such that those impacted also have the power to make a change. While those impacted would presumably be aware of the impacts, the awareness scope could be a bit larger than the impact or power scopes. The success of this approach that has been achieved with government support suggests a congruence of all three scopes, but if the power scope is ultimately controlled by one group, this can bring it out of congruence with the impact.

Diversification of local livelihood strategies

The assessment of local livelihoods in SAfMA (Fabricius et al *in prep*.) indicates that people cope with ecosystem change through strategies to reduce their risk. They become seasonally and spatially mobile and flexible, and invest in landscape diversity rather than monoculture. They also diversify the household labour force, and invest in formal education. People also scale down, by reducing herd sizes and field sizes. People may try to forecast the future, but in this they are less successful than in planning their day-to-day activities. They may rely on rumours or superstition to forecast. People also form local institutions, to help them deal with uncertainty. They fall back on traditional customs and rules, but also form new cooperatives such as burial societies, savings clubs, and self-help groups. Religion plays a more important role in their lives than before. People also gather often frequently for oral communication.

Another strategy is to adapt management practices. People try new enterprises e.g. eco-tourism, and increase their off-farm incomes. They also explore new technology, such as water tanks, ploughs, and mechanized pumps. As a response to shortages, people broaden and

extend their definitions of food, fertilizer, and fuel. They reduce overheads drastically, and tend to spend all their efforts on food security and basic needs.

Rural households and communities interact with and respond to their surrounding environment in innumerable different ways, depending upon the ecological, social, and economic contexts prevailing at any given time. They are both reactive to unanticipated circumstances, as well as proactive in optimizing opportunities and minimizing risks to sustainable livelihoods. Coping strategies and adaptation common to the three SAfMA local assessment sites include:

- A diversity of livelihood strategies
- Temporal flexibility in the livelihood portfolio
- Internal stratification
- Links to urban centres
- Multiple landscapes and environments; multiple resources and species from each environment
- Resource and species substitution
- Secure water resources
- Mobility
- Social and kin networks

The diversification of livelihoods is about making trade-offs. Trade-offs can save people's lives; in difficult times they invest everything in basic needs and security. Trade-offs also increase their vulnerability if they sacrifice future options to make such an investment. People are likely to be in a more favorable position to make trade-offs with increased awareness or power to control or change an impact.

Adaptive management brings awareness, impact, and power into congruence through the maintenance of options. Understanding and maintaining options leads to a broadening of awareness, and the ability to anticipate the shifting of (and perhaps even shift) scopes so that options can be maintained.

Expanding our awareness scope: Shortcomings with the model and potential improvements

[Discussion of successes and failures achieved in the examples above]

[Discussion of the importance of adding feedbacks to the model]

Practical guidelines

What have we learned that can make responses more effective or useful under these conditions? SAfMA offers some suggestions based on our observations of the consequences of the myriad responses (and non-responses) that have led to the current state and trajectory of the countries and communities of southern Africa.

1. Uncoupling the bits of any system to understand how they work or respond and then how to intervene in them is a tried and well-understood mechanism for dealing with complexity. But it is only when they are put back together as whole systems that any

intervention is really tested. Scenarios and model provide useful tools that SAfMA teams have used to achieve this end.

2. Current theory tells us we do not need to know everything about a system to understand its likely behaviour and responses. We only need to know about the handful of system governing structures and processes are that control system state and behaviour. We can thus structure our need for information hierarchically and adaptively. We do need to know everything we can about the system governing structures, processes and events and how they are coupled. These are the slow variables. We can structure our knowledge of the faster, finer resolution components of the system on an as needed basis. Learn what we need to know when we need to know it.
3. Dealing with proactive behaviour is exceptionally difficult. In the SAfMA experience what appears most likely to succeed is to give people themselves power and make them accountable. This means making policies that make people responsible. This is likely to be very hard for everyone to do. People want to be able to collect the benefits of being in control but do not want to absorb the costs (including from unpredicted extreme events). This is rational. But societies as wholes need to make choices between local, responsive governance and control, with all the consequent costs, or more centralised control and cost sharing.
4. SAfMA as a whole acknowledges the need for providing decision makers with options. There is no one best solution, no magic bullet and no miracle cure. So decision makers at all levels and scales need options. SAfMA has focused on trying to provide options at multiple scales and to look at implications of some of these across scales.
5. Responses need to be targeted at the (dynamic) state of the system. We need to know where it is in the "state space" defined by system governing structures and processes. This requirement adds a burden of understanding on the decision maker but it is our experience that this burden should be offset by the improved efficiency in implementing effective responses.
6. Many of us have become desensitised to pleas for longer term planning and research. We are desensitised because these pleas almost always fall on deaf ears. Donors, governments, and much of civil society have short time horizons. But longer-term processes and focus need to be maintained. SAfMA has not really focused on these longer-term processes and issues other than through scenarios and through enhancing local capacity. What more could be done? We need to identify the agencies and organisations responsible for long term planning. SADC, NEPAD and several universities may well be the best repositories of long-term data sets but also for long term planning. This does not guarantee that they will do it, so we need to seek alternative approaches to long-term planning and information generation.
7. Human capital in the region is limited. In some countries, such as Zimbabwe, it is declining very rapidly. Perhaps it is naïve to expect institutionalised processing of complex systems in situations like these, in which case we must acknowledge this and devise alternative strategies to deal with complexity.

Conclusions

Problems of complex systems need complex solutions. Enlightened policy makers or managers would do well to initiate policies or activities which bring about the greatest possible congruence in the scope of impact, awareness, and power. None of these in isolation will likely succeed. Partial solutions to complex problems are unlikely to work. Through

managing these scopes, managers and policy makers will provide an environment in which the adaptive capabilities of a system are themselves harnessed to achieve effective solutions.

Where this is not possible, policy makers and managers need to pay heed to the system governing structures and processes. An effective response is likely to be one in which each of the system governing structures or processes is addressed to bring about the desired change. This is a complex and difficult task. However, unless this is done, and in fact even if it is done, we are unlikely to be able to predict outcomes. By far the best solution is likely to be to enhance the adaptive capacities of the system itself through bringing about congrue nce in impact, awareness, and power scopes.

Acknowledgements (in development)

SAfMA, UAGs, MA

References (in development)

Basson 1997

DWAF 2002

DWAF 2003

Fabricius et al *in prep*.

IGD 2002

Kahane 1992

Redman and Kinzig 2003

Rogers et al. 2000

SARDC 2001

Turton 2003

Versveld et al. 1998

WDPA 2003