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Science tools to inform regional investment decisions – more than 'toys for the boys'?

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Abstract: Environmental investment decision making requires integration of a range of information sources including considerations of bio-physical and socio-economic factors in addition to political and institutional constraints. In Australia regional bodies (catchment management organisations, named differently in various states) are chartered with making investment decisions about environmental problems. Despite the complexity of environmental problems and the important role science can play, use of science tools is generally poor. This paper focuses on why science can fail to be used effectively to inform regional decision making and we offer suggestions for scientists seeking to have impact based on our experience.

Lack of adoption of science tools occurs for a number of reasons often related to a lack of research culture and technical capacities of staff as well as inadequate involvement/ active engagement of tool developers with regions from the outset. Science tools which have a good chance of helping regional/catchment organisations should have features of 'profound simplicity', meaning being as useful as possible for the purpose (high utility) and whilst being as simple as possible. Scientists who wish to influence investment decision making should consider the following: the vision for the tool, the target audience, whether the tool helps decision makers to answer relevant questions, development of relationships, involvement of the intended users from the outset, ease of use of the tool and requirements for training and support. Participatory approaches involving non-technical specialists and other disciplines can increase use and impact of tools.

Two tools (the Salinity Investment Framework, SIF3 and the Investment Framework for Environmental Resources, INFFER) which have had an impact on regional/catchment investment are presented as case studies. SIF3 met the condition of 'profound simplicity' as an integrated tool, based on mature strands of biophysical science and socio-economic understanding. It was developed without participation of the users, although trialled using participatory partnership with two regions. SIF3 was successful, substantially changing the decision making of one region, but it did not fully meet regional/catchment investment decision making needs which needed to consider multiple environmental threats, not only that of salinity.

INFFER was developed in response to demand. We were faced with the decision to develop a tool rapidly to meet the regional needs or retreat to a more traditional scientific mode of developing an information base first, which would have resulted in a missed opportunity to further influence decision making. If INFFER was to be adopted by many regions we knew it needed to be relatively simple. INFFER was designed in partnership with regions and is modified in response to use/needs. Training and on-going support was also seen as important from the outset. INFFER is now being used or trialled in at least 15 regional/catchment management organisations. The project has had an impact on regional investment decision making and we have also maintained a strong publication record.

Keywords: *Applied science, catchment management, integration, policy, simplicity*

1. INTRODUCTION

Catchment managers and others (governments, non-government organisations and community groups) are faced with deciding how to best invest public money to achieve environmental or other outcomes. Given the failure of the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust (NHT) to demonstrate environmental outcomes (Auditor General 2008), and community concerns about the environment, scrutiny about the effectiveness of investment will increase.

Environmental problems are 'wicked', meaning that there are no definitive 'right' or 'wrong' answers. There are issues of uncertainty and multiple, sometimes conflicting, legitimate perspectives (Ludwig et al. 2001). For regional bodies (watershed or catchment management agencies) that make decisions about environmental investment key questions are how much to spend within budget constraints, on what, where and for how long? The 'what and where' and sometimes 'how long' parts are the usual domain of biophysical science, and indeed where many science tools can help decision makers. The 'how much to spend and for how long' part of the question is concerned with budget, economic and governance/strategic/political decision making factors, things that bio-physical modellers don't often get heavily involved in, but need to know enough about to target how science is used to help decision making.

Scientists and modellers have no trouble agreeing that environmental investment decision making should be based on sound research. A mantra of 'evidence-based' decision making accompanies most government and regional programs in Australia and overseas. Science is however, only one input into decision making processes about how to tackle environmental problems. Economic, social and political factors are crucial, including issues of values, equity and social justice (Ludwig et al. 2001).

This paper focuses on issues around why science often fails to be used effectively to inform regional decision making and offers suggestions for scientists seeking to have an impact, based on our experience in Australia.

2. SCIENCE USED BY REGIONAL BODIES

2.1 Responsibilities of regional bodies

Different institutional arrangements for regional/catchment management exist in Australian states (Pannell et al. 2007). Understanding institutional arrangements, especially the relationship between regions and state governments, is useful to understand the potential influence of science in decision making.

Regardless of the institutional arrangements, Australian regional bodies have two main roles:

- To engage the community in participation and understanding in natural resource management
- Development and implementation of regional catchment strategies (named differently in different states) to address natural resource management issues to achieve environmental outcomes

Regional/catchment bodies have complex and broad ranging responsibilities, always with small budgets in relation to the size of the task, and under constantly changing state and national policies and politics. The strategic decision makers of these bodies (Boards and senior staff), often do not have strong technical science backgrounds and are inexperienced in differentiating science information and products. It is not difficult to see why science often forms a minor input into investment decision making and why it is often not used well.

2.2 Use of information to inform decision making

There is a large range in the capacity of regional/catchment bodies across Australia, with different levels of staffing expertise (Robins and Dovers 2007). In a study of the processes and information used, conducted in 18 regions covering six states, Seymour et al. (2009) concluded that the use of biophysical information was strongest, but mainly confined to resource condition assessment for management and monitoring. Use of economic information was very poor and social information had variable use but no clear role in decision making. Despite the availability of modelling tools, only one region used sophisticated modelling techniques. Almost no tools were used to predict environmental consequences of interventions.

Information used by regions was mostly from non-peer reviewed literature. State agencies were the major source of biophysical information, with only five of the 18 regions having partnerships with universities, and two with CSIRO.

Integration of information in regions seldom occurs within a formal process, or using a formal decision framework. This task is often seen as the responsibility of officers involved in monitoring, evaluation and reporting (MER); unfortunately this is commonly related more to reporting, rather than planning and prioritisation (Seymour et al. 2009). In our experience MER is often disconnected from decision making.

Our experience suggests that regional/catchment management organisations lack a research culture, often:

- being non-discriminating purchasers of science – inexperienced in distinguishing between high and poor quality, not asking for short interpreted summaries, and not reading reports
- poorly defining questions. This can lead to the wrong tool being used, and frustration by both the scientist and the region, where the science product delivered does not match the region’s needs
- not actively seeking the latest information
- using ‘favourite’ scientists, usually consultants who can respond to short time lines

Seymour et al. (2009) show that research and modelling tools are not having a major influence on regional investment. Suggesting that most science and modelling tools developed for regional/catchment application are ‘toys for the boys’ is probably unfair, because most scientists don’t set out to create tools simply for their own enjoyment. Lack of adoption of science tools occurs for a number of reasons often related to a lack of research culture and technical capacities of regional staff, but also due to inadequate involvement/ active engagement of tool developers with regional/catchment groups and understanding of their needs from the outset.

3. SCIENCE AND SIMPLICITY

As outlined earlier environmental problems require consideration and integration of multiple sources of knowledge and information. Even relatively simple problems may have complex non-linear behaviour, and the advances in computational tools mean that dealing with dynamics in time and space and a network of interactions is now possible (Mangel and Levin 2005). This suggests a need for complex approaches.

Despite the need for complexity to inform understanding, for science to have a chance of being used to inform decision making, it should be, in the words of Albert Einstein, ‘as simple as possible and no simpler’ (Ward 2005). Ward (2005), adapted by Lefroy and Pollino (2009), developed a ‘simplicity cycle’, which is useful to think about in the context of development of science tools to inform regional decision making. Lefroy and Pollino (2009) identify 4 major zones within axes of complexity and utility, which can be used to represent the stages of development of science tools.

- Naïve simplicity – the starting point, to which complexity is added
- Requisite complexity – complexity is added only to the point where adding more does not increase the utility. From this point further development leads to confused complexity and/or profound simplicity, or iterations between them
- Confused complexity – development of science tools involves adding complexity and trialling to see if this leads to a better outcome. This can be an important part of the development process.
- Profound simplicity – moving to increasing utility with decreasing complexity involves synthesis and integration rather than creation of new elements. The idea is to prune and pare down the design so that only the essential components or function remains. The simplicity is built around an essential foundation of earlier complexity

Development of tools as close as possible to ‘profound simplicity’ will increase the chances of use.

4. WHO IS GOING TO USE MY SCIENCE TOOL?

Scientists and modellers develop some great tools, some even ‘passing’ the test of profound simplicity. Even though you (the scientist or modeller) think the tool is as simple possible, there is a fair chance that non-specialists might not agree. Insights from Pannell and Roberts (2009) about policy-relevant research are applicable; understand the target audience, practice excellent communication, be solution oriented, find a champion, avoid appearances of vested interest, and be simple, patient, persistent, resilient, responsive and timely. Most insights are about relationships and participatory processes, more than the quality of the tool.

Below are some questions to help assess whether your tool is likely to be useful in regional decision making.

- Do you have vision for how you would like the tool used?
  - Are you prepared to compromise? You may need to.
- Who is the target audience?
  - Do you have a relationship with the key people who will use or make use of the tool?
  - Do you have a relationship with the regional decision makers (e.g. regional Board)?
  - Has the target audience been actively involved in the tool’s development?
- How does it help decision making?
  - Are you sufficiently clear about how the region makes decisions currently?
  - Do you understand how your tool provides input to the decision making process used?
- Does the target audience think they need it?
  - Are they actively questioning their current approach?

  - Does your tool conflict with the current mindset and approach?
  - Do they understand the information your tool provides?
- Is it easy to use (simple or complex)?
  - Does it empower the users to make their own decisions?
  - How much ongoing support does it need?
  - How do you think on-going support arrangements might be handled?

Clearly few tools answer positively to all questions. However, considering them enables thinking beyond tool development into the realm of application and impact. As stated earlier we believe there are important roles for complex science products to help with regional/catchment investment decision making. We are also not suggesting it is essential, or sometimes even sensible, for developers of complex tools to always move directly into application and training. What is important to consider is how such complexity can be packaged and delivered in a simple enough form (e.g. summary reports interpreted and written in plain English) to enable informed decision making. Thinking about such matters at the outset can make a big difference to whether it has impact. For example it might help you think through:

- whether it is realistic for your tool to be used for regional decision making (avoiding frustration)
- whether you in fact wish to develop such applied decision making tools
- if you do, then whether you should get into the world of participatory research and development and start developing relationships with the target audience from the outset
- whether you need to complement your skill set with training, establish collaboration with applied scientists, trainers and/or top communicators, rather than think through application issues later

Ridley (2005) provides some insights about why scientists often do not develop the necessary skills for applied research. Ludwig et al. (2001) also makes the crucial point that science disciplines are important, but disciplinary boundaries can be a major impediment to making decisions about the environment. He uses the experience of ecological science where large progress has been made by excluding humans from its scope, but that decisions about species conservation cannot ignore issues of human encroachment.

5. CASE STUDY EXAMPLES

5.1 Case study – the Salinity Investment Framework (SIF3)

Development: SIF3 arose from researchers from several disciplines wanting to clarify the role of plants in dryland salinity management and to think about the effectiveness of salinity policy. Research understanding in strands of biophysical science (role of plants, prominence of engineering, groundwater responsiveness) and socio-economic factors (few sufficiently economically attractive plant options, unrealistic expectations about on-farm adoption) was becoming mature. Additionally there was nervousness about the dominant policy response being used, with heavy reliance on small incentives and extension, and funding spread too thinly to achieve outcomes (Pannell 2001). The resulting publication (Ridley and Pannell 2005) became a decision framework aimed at helping regions make cost-effective decisions about investment for dryland salinity outcomes. Some of the features of SIF3 are summarised in Table 1.

The thinking for SIF3 originated from WA, building on previous work (e.g. Sparks et al. 2006, and others), where the state and regions had faced up to the environmental and political reality that it was not possible to save all environmental assets and limited funding should be directed to outcomes with high public benefit.

In terms of the ‘simplicity cycle’ the strands of biophysical, economic and social science had reached a point of maturation each of which could be described as having evolved from initial naïve simplicity to ‘requisite complexity’. The strands had not been integrated, and there was confusion and contested debate within the biophysical sciences (particularly agronomists, economists, engineers, and hydrogeologists). Debate, questioning and understanding the implications that work one discipline had on others led us to integrate the strands into a coherent and logical framework which was able to be generalised for any particular location. The resulting framework, which became known as SIF3, used four decision tables/trees for each environmental asset under consideration. Figure 1 illustrates the decision tree approach, with an example of factors that need to be taken into account to assess the policy response for investment to protect a waterway.

Implementation: We thought SIF3 would be useful in regional/catchment decision making. We had a vision for the tool, had identified our target audience, and knew the questions the tool could help with. We had not, however, engaged regions in its development and knew that it would challenge current approaches.

Trialling SIF3 was important to see if it worked and, more importantly, if it changed decision making. To increase our chances of success, we chose to trial it with two regions (one in Victoria, one in WA) who were questioning outcomes from current decision making. We knew there would be setbacks because the approach challenged the current paradigm, and thus having supportive institutions was important. Trialling was successful, changing investment decisions (Roberts and Pannell, 2009).

Whilst regions had not participated in the development of SIF3, they had been briefed about the potential for challenging recommendations. We, the tool developers, developed recommendations for partner regions, rather than empowering them to use it directly. Given the demands of regional bodies, the challenging nature of recommendations and in light of our experience with INFFER, this was a sound decision. Staff did not have sufficient ownership, or in some cases technical capacity, to develop recommendations themselves.

Whilst having a good tool was important, other factors were more crucial in getting it used for decision making. These included strong support from the region (particularly at Board and Chief Executive Officer levels), an adaptive participatory approach to establish trust and credibility, regular communication and responsiveness to issues of concern as they arose. Participation can be very time consuming, Newham et al. (2006) reported that it accounted for around 30% of total research effort in an integrated catchment study. Participation and communication were more difficult and time consuming than the application of SIF3 itself, and at least as important (Roberts and Pannell 2009). Trialling was so successful in the Victorian CMA that we were asked to develop a tool to encompass multiple environmental threats. This became INFFER.

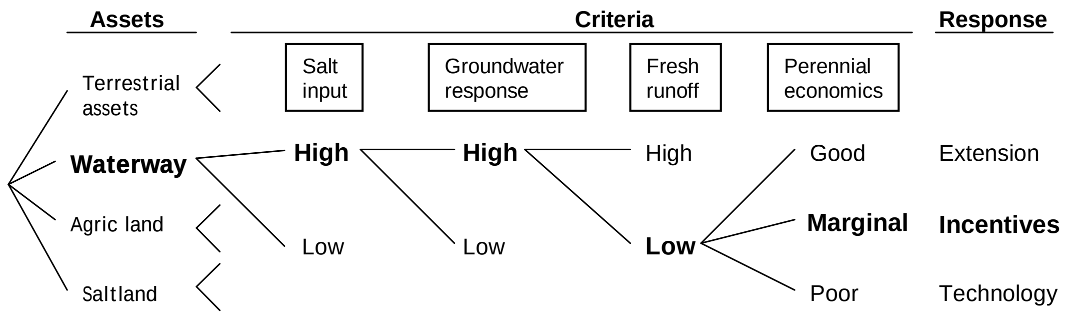

Figure 1. Illustration of the SIF3 decision tree used as a simple tool to guide environmental managers and policy makers regarding public investments in salinity management or mitigation.

Table 1. Characteristics of two tools used to inform investment decision making at the regional level

	SIF3 (Salinity Investment Framework)	INFFER (Investment Framework for Environmental Resources)
Vision	Integrated, rigorous approach to helping achieve cost-effective dryland salinity outcomes at regional, state and national levels	Rigorous and transparent cost-effective use of public money to achieve environmental outcomes at regional, state and national levels. Underpin investment where achieving cost-effective outcomes is the aim
Type of tool	Users work through decision tables/trees to come to appropriate policy response	Principles, well defined process and a project assessment form which uses available information to integrate biophysical, socio-economic and political/institutional criteria to enable assessment of project cost-effectiveness
Target audience	Regional bodies and government (state and national)	
What questions/decision making does it help with?	Assists with identifying cost-effective public investments for dryland salinity. Feasibility studies and costed projects are also required for investment decisions	Assists with identifying cost-effective public investments for all environmental threats. Output is a cost-effectiveness index for each project, and a costed project using appropriate policy tool(s)
Does target audience think they need it?	Created by scientists in response to poor outcomes from public spending in NAP/NHT. Two regions trialled, now superceded by INFFER	Created by demand from users. Now being used to make investment decisions. Now trialled in 15 CMA regions. Appears that it may become a government- recommended approach in Vic and WA.
Ease of use[A]	B-C, in pilot application has been applied by experts. If used directly by regions basic salinity training would be required.	B-C, training is required and the user needs to access information from a range of sources, and/or seek opinions from a range of technical experts. If it becomes embedded in institutions in time, then ease of use will become B

[A] A=Simple, the user can use without training; B=Simple-Intermediate, training required, but the user can then use with little/no further modification; C=Intermediate, training is required and interaction with the developer for modification; D=complex, used by experts.

5.2 Case study – Investment Framework for Environmental Resources (INFFER)

Development: Unlike SIF3, INFFER (www.inffer.org) was developed in response to demand from users. The timing was right for them, but less so for us if we followed a traditional research path. The NAP and NHT were concluding, and the regions wanted to be in a strong position to respond to new programs, given emerging signals about the need for more rigour and achievement of outcomes.

The major challenge with INFFER was that, unlike for SIF3, we did not have time to go through a process of understanding the body of existing research work, let alone synthesising and integrating biophysical and socio-economic factors related to the environmental issues we wanted to deal with (water quality, biodiversity, and pests) to underpin a decision framework. In terms of the simplicity cycle, we could not move from the naïve simplicity to requisite complexity, let alone getting to a state of profound simplicity. We were faced with the decision to develop a tool rapidly to meet the needs of the region or retreat to a traditional scientific mode of developing an information base first. Retreat would mean a missed opportunity to further influence decision making at regional and state levels, as Victoria and WA taking a keen interest in our work.

Given that we had learnt much from SIF3 about the biophysical and socio-economic considerations for decision making, we decided to develop a tool based on principles in the short term, at the same time commencing work on underpinning bio-economic modelling (still under development, not part of this paper) that would eventually inform future decision frameworks. SIF3 did also not go far enough to help regions make investment decisions, in not providing advice about prioritisation of alternative projects.

What we did to develop INFFER was to:

- use the principles embedded in SIF3 (consideration of asset type, technical feasibility, socio-economic considerations, choice of policy tool)
- strip out the salinity related technical considerations
- acknowledge additional considerations decision makers should think about when making decisions (institutional constraints, unintended negative consequences, knowledge gaps and uncertainty)
- respond to regional need for the tool to help prioritise projects on the basis of achieving environmental outcomes within limited budgets
- participate in regional investment decision making, observing and providing input when asked to
- respond to the signals from Victoria, WA and the national program about protecting assets
- develop and adapt in response to needs, a framework that met the needs of transparency and accountability, whilst being relatively straightforward to use

INFFER uses a project assessment form (a standard template) which covers the main areas (in question and rating format) needed to be considered in decision making (www.inffer.org).

In terms of the simplicity cycle (Figure 1), because of the SIF3 experience (with both the tool itself and the learning through implementation with the regions), we did not start from a position of naïve simplicity. We were initially below the point of requisite complexity from the region's decision making perspective, but we understood enough about what additional factors needed to be added. We have deliberately side-stepped the move to confused complexity; this will come with current bio-economic modelling work. We have moved towards requisite complexity in adding additional elements, but have considered them simply (rating-based or text answers required in the project assessment form).

Another consideration which helped was that the regional/catchment groups were not concerned by a lack of underpinning technically-based decision support tools. Most of their current investment decisions do not use such tools. They were also used to making decisions based on imperfect knowledge and using whatever sources are at hand. Asking the right questions and getting the knowledge from wherever they could (underpinning science, expert and staff opinion) was more important to them than having a well developed underpinning scientific framework. In the short term, we have developed a tool that is consistent with this approach, but in the medium term we will develop tools that embed stronger science and modelling. INFFER is sufficiently generic and flexible that it can already accommodate information from whatever source is available; complex catchment modelling has already been used to inform investment decision making in several cases.

Implementation: Following SIF3, we had a strong vision for INFFER (Table 1). We wanted it to be a recommended approach at regional, state and national levels to underpin public investment aimed at achieving cost-effective environmental outcomes. Given our SIF3 experience, we knew that if INFFER was to be adopted it needed to be able to be used by people who came from different backgrounds and capabilities. Having a clear vision, as well as an active, participatory and collaborative relationship with users greatly assisted tool design. The emphasis on practical usage by non-expert users meant that we continually strived for simplicity and clarity in design of the tool.

We also decided to train people interested in using INFFER once the project assessment form was developed. We offered support through training, on going help support and a website. At least 15 regional bodies have trialled or are using INFFER. Whilst encouraging, without signals from governments, we believe INFFER will be trialled, followed by dis-adoption. Government requirements provide strong drivers to assist with tool adoption (Sharpley et al. 2003), and whilst the signs are encouraging in Victoria and WA, most regions have indicated that they will not adopt it without being required or strongly urged to do so by government.

6. CONCLUSIONS

Regional/catchment management organisation investment decision making about environmental problems is complex. Despite this few regions use scientific tools, especially sophisticated modelling approaches. Tools should be as simple as possible, with complexity added only when it increases performance. There are many reasons why regions don't make full use of science tools, including technical capacity, lack of science culture and inadequate involvement/ active engagement of tool developers with regions from the outset. Most issues associated with the poor use of tools are about relationships, participatory processes institutional constraints or incentives, and timing rather than the quality of the tools. Issues for modellers and other developers of science tools who seek to influence regional decision making include; consideration of the vision for the tool, the intended target audience, whether the tool helps decision makers to answer relevant questions, whether the target audience think they need help, developing relationships, involving them in tool development from the outset, ease of use and considerations of training and support. Participatory research approaches involving non-technical specialists and other disciplines will increase the use and impact of tools.

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