Making a difference:

science, action and integrated environmental research

By

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This paper is a summary of findings from doctoral research carried out at the School for Resources, Environment and Society, The Australian National University. For more detail on the study or findings, please contact the author (details last page) or see:

van Kerkhoff, L. 2002. *Making a difference: science, action and integrated environmental research*. Unpublished thesis. Australian National University, Canberra.
October 2002

This study was supported by:

Introduction

The challenge of integrated environmental research

One of the great paradoxes of modern-day science is that the credibility it relies on to gain authority is derived in part from its independence from decision-makers. Yet that independence is also impotence: to make a difference in the world, researchers must work with those who can bring about changes in action. In environmental and natural resource management there is growing awareness that to have a say in environmental decision-making—to make a difference—researchers need to get involved.

Consequently new models of science are emerging, many of which are variations on the idea of 'integrated research'. Yet there are currently no widely accepted understandings of what integrated research is, how it can be done effectively, or what might be the 'proper' role of science in an integrated approach? Increasing calls for integrated research in environmental and science policy (including research funding) mean that more and more researchers are confronting these questions.

Origins of the idea of integrated research

In part the uncertainty of integrated research is a result of its history. In the environmental context, integrated research has origins in work of the 1960s and 1970s that explored alternatives to the belief that scientific expertise alone could 'solve' complex problems in agriculture and development. This diverse body of work countered the scientific 'top down' expert advice model with 'bottom up' models that integrated the abstract expertise of scientists with the local expertise of land managers.

In a different, more recent development, there has also been a push towards greater connection between the sciences and, in particular, business and industry. The idea of the knowledge economy acknowledges that research is a vital component of the engine of economic growth. To achieve better economic performance, then, the more integrated science becomes with the rest of society, the faster and more efficient the conversion of basic science into new products and services will be.

Both of these social changes underpin the idea of integrated research as it appears in environmental and science policy today. While not strictly mutually exclusive, they do make different assumptions about the processes by which science can and should be integrated, including, for example, whether knowledge should be shared freely, or protected as a valuable commodity. Thus integrated research is, historically, a complex and multi-faceted concept, which contributes to the present-day confusion.

About this study

This study aimed to clarify our understandings and practices of integrated research—what it is and how to do it well—by investigating how integrated environmental research is actually done. It involved in-depth study with two Australian environment sector research organisations with a mandate to do 'integrated research'. Both were Cooperative Research Centres (CRCs): the CRC for Coastal Zone, Estuary and Waterway Management (the Coastal CRC); and the CRC for Greenhouse Accounting.

CRCs are natural science and engineering research organisations formed by formal agreements between extant organisations ('core partners') and the Australian Federal Government. They are designed to bring together researchers and research "users" (such as government, industry and community) who are involved in similar problem areas, but dispersed across different organisations and locations.

CRCs are unique in several ways. The partner organisations that make up a CRC may comprise a wide range of research and non-research organisations and firms; their organisational structure insists on cooperation across those groups; and they have stringent accountability and reporting requirements that aim to ensure some degree of 'genuine' integration is being achieved.

CRCs are funded through competitive bids for government funding over seven years. For their application to succeed they must demonstrate cash and in-kind commitments from their prospective partners. Both of the Centres who participated in this study began operations in mid-1999.

This study began in mid-2000, and continued until early 2002. The findings presented here were drawn from in-depth interviews, observation, and document analysis.

Talk of integration

My first analysis was of the ways people spoke of integration as a concept. Study participants, including researchers, associated managers, and stakeholders, viewed integration in several different ways. While the details varied, people tended to speak of the concept of integration in terms of six different models.

1. Integration as a jigsaw

Piecing together the pieces of the knowledge jigsaw was a regular metaphor people used to describe their understanding of the concept. In this model, the integrative challenge was to bring together all the known bits of information about a system or problem, and also to identify what is missing. This characterised integration as overcoming the fragmentation of knowledge inherent in science, a search for a 'complete' picture, which would provide the solutions or answers.

2. Integration as linking silos

Similarly, people also used the idea of integration as linking silos of information, which may be disciplines or problem-sectors; linking understanding of aquatic systems with terrestrial systems, for example. This model did not seek a complete picture though. Rather it sought to select from those silos the information that could be used in a technical integrative tool, such as a computer model or decision support system. So the ways in which the silos came together were driven by the demands of the devices that were used to structure the integration.

3. Purchaser-provider integration

Purchaser-provider integration was also a structured approach to integration, but its structure was imposed by the legal and bureaucratic conditions of contractual research rather than the demands of a specific technical process. In this relationship the purchasers articulated a specific research need that

researchers provided; thus effectively integrating science and the context of the purchaser, typically government policy.

4. Integration as extension

In this model, integration was seen to be educative. Getting results out there so people could use them was a central idea. This model of integration focused on the recognition that part of the disjuncture between science and the non-science world was lack of effective communication between them.

5. Integration as value adding

The idea of integration as value adding was a more sophisticated version of the linking silos model, as it allowed for a range of different 'integrated products' to be produced at different stages of the integrative process. It built more complex integrated products over a series of steps, and each step offered a 'value add' that could be useful to decision-makers in different contexts.

6. Integration as a container

The final common model was much less structured, even unstructured. This model expressed the view that if you bring people together, and they find shared interest or expertise, they will 'naturally' integrate their work. The CRCs, for example, served as an organisational container in which people were placed to interact and collaborate. This was a rather romantic view of integration, emphasising serendipity and collegiality rather than structure and systematicity.

Each of these models, barring the last (which simply 'black-boxes' the concept), viewed integration as a matter of managing, designing, and manipulating information flows. Pieces of the jigsaw, silos, value-adding, extension, and purchase, were all concerned with positioning, directing and combining information.

As one Coastal CRC researcher said:

> *there is always going to be a range of… information that … is a basis for decision-making … I guess the integration is how well, and how early that information comes together for decision-makers to consider all aspects of an issue…*

Thus it was predominantly conceptualised as a technical issue, of 'getting the information structure right'. This is significant as this also shaped the way people conceptualised the *problems* of integration. If integration is about information flows, then difficulties were to be resolved by re-engineering those flows.

The Greenhouse Accounting CRC, for example, reorganised its programmatic structure at the end of its second year, in response to external changes and the perception that the programs were at risk of turning into self-contained silos.

However, while information flows were important, many participants also recognised that there was far more to integration than that.

Doing the integrating

To work out what the 'more to it' was, I turned to examining the ways people spoke about the experience of doing the integrative research. Participants identified a number of personal and professional challenges they had encountered. These suggested that social and political factors were also crucial to the processes of integrated research.

Social skills

Integration was built on human relationships that are uncertain and often unpredictable. When

groups were forming, key factors in the 'getting to know you' process included trust, respect, fairness and transparency. Trust and respect formed a kind of interpersonal groundwork that enabled the actual research to happen. People also identified transparency, fairness and communication as key aspects of integrative teamwork. These were important as they allowed people to assess the ongoing development of their relationships with each other and the Centres.

As one researcher said:

… integration success is based on alliances of people which are based on trust and good will …

These general issues, however, are common in many collaborative environments. They were particularly difficult in integrated ones because people had to manage these issues across different backgrounds, including disciplines and organisations, but also backgrounds that may or may not include scientific training or expertise.

Leadership

Leadership was a key factor in the development of integrated research. Given the range of ways of integrating, there was considerable uncertainty among participants as to what they were getting into, and what they should be doing. Leaders reduced this uncertainty by presenting an inspiring vision of the kind of integration that the researchers would be engaged in. This also helped to manage the expectations of what could be achieved.

As the Greenhouse Accounting CRC's vision was in part defined by its relationship with its major stakeholder, there was a lot of uncertainty among researchers until the nature of this relationship had been resolved.

Multiple identities

At the individual level, some participants noted that integration could affect one's sense of identity. People spoke of having to juggle hats, to adopt different personas when speaking with scientific colleagues than they did when negotiating with policy-makers, community stakeholders or industry representatives. This was exacerbated by people dividing their time between CRC work and work for their main employer.

One research leader described four quite distinct 'hats' he needed to wear in professional life in and out of the Coastal CRC. One also noted that the CRC itself may need to have multiple identities, if it is to meet its own goals as well as those of the CRC Program.

These accounts suggest that the technical issues noted in the talk of integration, and the practical issues of social and political sensitivity, were typically viewed as separate. Even where people acknowledged their interconnectedness, there were few concepts they could use to talk about or analyse them in a connected way.

Linking social and technical

So how did the social and technical aspects of integration come together? Clearly in actual events the technical and social were simply two parts of the same process. In the next part of the analysis, I looked at how these two aspects were reconciled in practice. By exploring several different 'integrative' events, a key common theme emerged: people reconciled the social and technical gap by the ways they construed and participated in (or sought to participate in) change. That integrated research aims to bring about change goes virtually without saying—why would it be otherwise? However, the assumptions behind how research *achieves* change are complex and

varied, obscured as a 'goes-without-saying' aspect of integrated research activity, yet central to its purpose.

There were three notable contexts of action that researchers used to structure their approach to integrated research. The first was change on-the-ground. This was actual, observable change in land management practice. It is well established in participatory research literature that landholders or land managers who have been directly involved in research are more likely to change their practices than those who have not. Specific research projects were often closely connected with specific management decisions, and designed to inform those actions.

> The Coastal CRC designated three management study areas, or geographic regions. This allowed researchers to identify and work closely with local stakeholders to work out what research was needed to improve waterway management in these areas.

Yet while there are some managers responsible for large tracts of land or water resources, or large point source of pollution, in many instances environmental degradation is the result of the small, dispersed actions of many individuals, only some of whom can be directly involved in research. So although research that directly involves and influences on-ground management can be very powerful in bringing about change, this change is often limited in terms of space or people involved.

The second action context was political change. Researchers could seek to influence government policy, or policy-makers would seek out research to guide their decisions. This form of change was one step removed from change on-the-ground, as the implementation of policy then in turn influences actual environmental management practices. This removal meant that researchers had less direct influence in achieving change, but could have greater indirect influence as policies tend to affect a wider scale and more aggregated groups of people than the local-level projects.

> The Greenhouse Accounting CRC, for example, concentrated on working with high-level stakeholders such as the Australian Greenhouse Office, as emerging national policies would later shape local responses.

The third type of change was academic change, or change in the state of scientific knowledge. Of itself, this influenced future research, but did not have a direct influence on an action setting. However, academic change could be used in turn to influence policy decisions through researcher participation on advisory committees and similar 'expert' roles. (Or, potentially, on-the-ground decisions, although this was less likely as the local context was often too far removed from the typical academic level of abstraction.) Indeed, academic change held more credibility in controversial political arenas, as researchers could claim a level of disinterestedness that those engaged in the more direct routes could not.

> Senior research staff in the Greenhouse Accounting CRC, for example, were invited to participate in the international negotiations on the Kyoto Protocol, by virtue of their role in developing the underlying science.

The connections between research and the ways it can bring about change are part of the underlying suite of assumptions that frame the practice of integrated research. These three different ways of approach change carry different implications for the design and conduct of integrated research. Categorising research practice according to the different action contexts that were targeted by researchers offers a way of understanding the diverse approaches to integrated research that crosses the social/technical divide.

These relationships are illustrated in Figure 1.

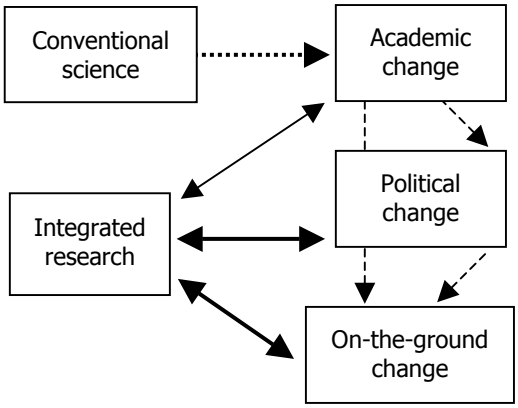

Figure 1. Pathways to change

Working out which is the most appropriate pathway in Figure 1 for a given situation gives a more comprehensive framework people can use to design or assess integration. Different sorts of leadership will be required for each path, and different identities will need to be reconciled. It can also offer some insights into how and why different interactive approaches may or may not achieve the change they aspire to.

Yet it also raises another swathe of questions. How can research planners more deliberately bring joint consideration of the technical and social aspects of action contexts into their development of integrated research projects or programs, in different action contexts? How can different action contexts be targeted? How can integrative processes be designed?

Designing integrated research

In conventional research the relationships between science and change are generally simple. Researchers do the research, and once it is done, it is presented to research users, who then apply it. This simplicity is enabled by the disinterest of the researchers—responsibility for application lies with the users. In integrated research, researchers become committed to making a difference, and so the relationship is more complex.

To be effective in bringing about change, researchers need to know how their partners in the relevant action contexts can (and cannot) act. In other words, researchers who designed their research with a detailed understanding of the change context in mind, were more likely to develop relevant or influential research results. Integration allows people to *act into* zones that are not their own—research gains influence through adopting the influence of others.

Non-scientific research partners can be understood as having a zone within which they can effect change. This 'zone of change' can be narrow or broad; narrow examples include contract research that is designed to make a small, specific contribution to a decision-making scenario. Broad examples include policy priority- or agenda-setting, where there are significant opportunities for research to influence decisions. However, in the cases, change was typically opportunistic rather than strategic, and the capacities of research partners to implement change were rarely identified systematically.

> The Coastal CRC did conduct strategic planning workshops with stakeholders, but these tended to seek out how existing interests coincided, rather than strategically targeting new areas.

To complicate matters, these zones of change are not static. They are influenced not only by the interaction itself (researchers and action-takers may discover new opportunities for change through their interactions), but also by external factors. Likewise, of course, research is not always

predictable, or stable. Surprising research results could affect both science and action.

In the cases, to integrate successfully with this doubly-dynamic system (dynamic within the scientific research context, but also dynamic in the other action context) was a complex and difficult task. Managers or directors of research often had a good intuitive understanding of the strategic development of the action contexts that were relevant to their field of research. Where change was rapid, research programs were designed to respond not only to current scenarios, but *future* scenarios.

> The Greenhouse Accounting CRC, for example, needed to design a research program that would still be relevant regardless of the outcomes of international debates under the Kyoto Protocol, and national policy decisions like whether Australia would sign up to the Protocol.

Yet to date we have relatively few concepts that can help incorporate this level of dynamicism more formally into research planning. This means that the skills to do this level of planning tend to remain intuitive, and cannot be readily taught or learned.

Infrastructures and trajectories

To capture the temporal aspect of the interactions between research and action contexts, the ideas of infrastructures and trajectories can be useful. The institutions of 'science' and 'government', for example, can be regarded as operating within particular infrastructures, suites of rules, conventions and context that give an activity meaning. These infrastructures develop and shift over time—infrastructures are not static, but moving along trajectories through time. The idea of trajectories suggests change, but change that is constrained by the past.

Within these larger infrastructures, individuals and groups develop their own trajectories. These smaller trajectories can interact across the boundaries set by the infrastructures—integrated research can be understood as small groups weaving their own personal trajectories together across the traditional infrastructures that bind larger organisations or institutions.

Yet while there are opportunities to cross the boundaries of existing infrastructures, there are also limits, which form *constraints and opportunities for action into the future*. The idea of infrastructures and trajectories, by emphasising that integrated research planning needs to consider both the past and present infrastructures, can help to identify likely future possibilities for change. Understanding where action partners are *going* as well as where they are coming from, can improve the capacity of integrated research to make a difference. It can also be used to strategically assess the likely effects of different research strategies and topics under different possible scenarios.

Designing for change

In this section I build on the ideas of infrastructures and trajectories in a number of concepts that may be useful in designing and doing integrated research. These emphasise the process of engaging in integrated research, and how this process can inform research planning.

Getting involved: entry points

While it was common for study participants to think rather romantically of integrated research as resulting from a chance meeting between two people who serendipitously mention their similar areas of interest, in practice this is a highly inefficient and unreliable basis for integrated research. Instead, because outsiders often view

science as a closed system, integrated research design needs to create readily identifiable *entry points* that people outside the scientific institution can recognise and feel invited to take up. Entry points are avenues for participating. To be effective they need to be widely recognised *as* entry points, manufactured gaps in the infrastructures of traditional institutions that individuals can pass through.

> The Coastal CRC's management study areas created entry points, as they signalled a commitment by the researchers to a particular region. This region then formed the basis of common interest—literally, the common ground—from which they could negotiate relevant research with local stakeholders.

At the smaller scale, however, entry points *and their consequences* become far less clear. Can non-scientists legitimately participate in the 'scientific' research, or do they have to become part of the study in the sense of *being studied* (the 'let's get a social researcher in' scenario)? Is data collected by a community-based group of volunteers of sufficient reliability to use as a basis for a scientific paper? Should contract research over which the research organisation has little control be allowed to consume significant proportions of available resources? These entry points in the cases of this study were in hot dispute, and there were no clear answers. Integrated research designers need to consider the consequences of inviting people to participate in different ways.

Also, of course, getting people involved is only the first step. What happens next?

Maintaining momentum

While entry points create opportunities for integrated research, they alone will not generate a successful, integrative relationship over time. Supporting infrastructure needs to be provided to ensure newcomers have a genuine say in how the research unfolds, according to timeframes that make sense to them. Infrastructure in this sense is a suite of identifiable processes that participants can engage in that gives context and meaning to their involvement, such as regular meetings and identified mechanisms through which their input is considered.

> Both CRCs were able to generate considerable enthusiasm and initial support for integrating their work—the follow-through was more difficult. The sheer administrative complexity of resourcing these complex collaborations caused both Centres to lose some of their momentum. Delays in funding and bureaucratic red tape frustrated both researchers and stakeholders alike.

When people change their trajectories to leave conventional infrastructures, they lose much of their traditional support base. New infrastructures are needed to provide that support if they are to continue. Anticipating bureaucratic tangles, and employing staff that have the expertise to set up appropriate administrative systems quickly and efficiently at the outset may help. Maintaining communication amongst all participants can also help to manage expectations about the processes involved, reducing frustration.

Over-designing

If there are risks in under-designing support for integrative trajectories, there are also risks in over-designing. Much of the value of integration lies in allowing, encouraging, even forcing interactions that generate innovative projects. Participants need to be able to follow up on these new ideas. This requires balance between creating a social and administrative infrastructure that support interaction and good relationships, and one that stifles it through lack of flexibility.

> One researcher suggested that the Greenhouse Accounting CRC had committed to too many milestones in the bid process, leaving too little

flexibility to follow emergent synergies or opportunities for change.

While some engineering is necessary to allow the creativity to happen, too much can limit the participants' capacity for innovative collaborations, as trajectories become so tightly coupled that people cannot follow up any new opportunities that may emerge.

Identifying opportunities for change

Explicitly identifying what those new opportunities for change might be can be useful in this regard. However, gaining and using an understanding of a partner's (or of several partners') action context can be a complex matter. In many instances throughout the analysis of these cases, sources of conflict and tension between researchers and stakeholders could be traced to inaccurate understandings of how their how partners' could or could not take action. Looking forward over time, identifying and understanding opportunities for effecting change can enhance the research designer's or manager's ability to target some changes and avoid others.

Each of the Coastal CRC's management study areas, for example, offered different opportunities for change. One already had structures and processes in place for research to feed into local government policy; one had an active industry community who were eager to engage with the CRC; the other was dominated by community and landholder interest. This meant that there was no 'one-size-fits-all' strategy for integrating research with stakeholders in these three areas, as the key partners all had different capacities to bring about change in their communities.

Looking forward into the future, each potential integrative partner can be understood as operating within an imagined range of future possibilities. Integrated research can tap into those possibilities for change. Some of these possibilities will be known, others may emerge as new insights are learned from working together.

It is common for integration to be phrased in terms of *synergies* and the emergence of new opportunities for change is an important type of synergy that integrated research can aim for. By working together researchers and stakeholders can open up a wider range of possibilities, a wider 'zone of change', if you like, than would have been possible in isolation.

While few would deny that maintaining good relationships is hard work, the concept of zones of change offers some sense of why this hard work may be worthwhile—and when it may be less than worthwhile. Work to identify how different partners can exert influence in the world may illuminate a wide range of strategic trade-offs useful for integrated research participants to consider.

Reverse planning

In this sense, a design process that starts from the desired end—the change one hopes to see—rather than from the beginning, asks different questions. Rather than starting with 'how can we get stakeholders on board?', planning starts with questions of 'what *can* we change?', 'what do we *want* to be able to change?' and 'whose trajectory can we tap into to achieve that?' Moving backwards from this point, research designers can then strategically pinpoint who they need to involve in their work.

Strategic partners may be people who have already defined a need for research, like the Greenhouse Accounting CRC's partnership with the Australian Greenhouse Office. They may be people who have not considered how research can complement their own zone of change, such as some of the community groups involved with the Coastal CRC. Different partnerships offer different opportunities to effect change, which will also affect research planning.

The risks and benefits of different strategic partnerships can be weighed up—partners who have defined a need for research may be keen to be involved, but they may also have set ideas and processes that the research partners must conform to. Where there is less immediate interest more groundwork may be needed to generate enthusiasm, but the researchers may have greater influence here in the form and structure of the partnership. Understanding these constraints and opportunities may help researchers to *select* partnerships that are appropriate to their own research goals.

Then, finally, consideration closer to the present may lead to the fashioning of appropriate and attractive entry points that will allow the imagined future (or some recognisable version of it) to emerge in reality.

Ramifications of change

Cooperative, integrative research has a capacity to carve out its own space in future change that is as broad and as limited as the ability of its partners to bring about jointly desired differences.

Yet freedom and influence are not just one-way. Research itself is also inevitably changed. While the specific ramifications of moving from conventional to integrated research will be different under different circumstances, researchers need to consider what they might be.

Common ground in shared action contexts and the effects of research within those new boundaries can replace traditional criteria for success. Becoming active contributors to localised political arenas gives researchers a political voice in contrast to their traditional role of impartiality and neutrality. Research programs that have been carefully crafted to fit with community, government or industry agendas can be challenged as suffering from a loss of scientific independence.

Different researchers will, of course, weigh theses trade-offs according to their own priorities. However, understanding that there *are* trade-offs is vital to generating realistic expectations of what it might mean to leave the confines of conventional science and engage in integrated research.

Four-dimensional research?

So how is integrated research different from conventional research? In many respects, the difference is one of emphasis, rather than strictly of kind, as features like trust, leadership and strategic thinking are not absent in conventional research. However, in conventional research they tend to be characterised as the peripheral to the main business of science. Integrated research takes a more expanded view of what constitutes science. The differences can be highlighted by characterising four dimensions of research.

The first dimension is the individual creativity needed to do innovative, original research. This is the core building block of science, and can be turned to either generating new fragments of knowledge (as in the conventional model of science) or integrating the pieces. The second dimension is the interaction among scientists needed to communicate new ideas and ensure quality control. Conventionally this emphasises disciplinary communities; integrated research emphasises interdisciplinary teams or tools like integrated modelling. The third dimension represents the larger social systems that science sits within. In conventional science, the boundary between the second and third dimensions (science and society) is actively maintained, monitored for signs of incursion of politics or industrial interests into the research. In integrative research, these incursions are actively shaped and, to varying

degrees, encouraged. The final dimension is change through time. In conventional research, the ways in which science makes a difference through time are not the concern of the researcher. In integrated research, leaders grapple with the uncertainties of how research and action contexts may change over time, and the strategic role research can play in shaping those future social-scientific scenarios.

This description of four dimensional research does not offer a clear-cut definition of what integrated research is—any part of the four dimensions can be integrated, or not—but it does allow the various distinctions between conventional science and integrated research to be specified and compared.

In general, integrated research represents the professionalisation of integrative activity, especially in the third and fourth dimensions. More formal, systematic approaches to the relationships between science and society, as well as consideration of influence and change over time, are hallmarks of this expanded view of research that seeks to make a difference.

In conclusion

As always, the greatest threats that confront the existing institutions of society are also its greatest opportunities. As a threat, integrated environmental research can undermine the independence and objectivity scientific research is founded upon. As an opportunity, it allows scientists and researchers to have direct influence in decisions that affect the biosphere and our ability to live within it. Managing the threats while grasping the opportunities is central to integrated research.

Achieving—or approaching—sustainability will depend on effective relationships between researchers and action communities. This study has started to work through concepts and processes that may help integrated research realise its potential of accelerating social change. The better that society as a whole can understand and negotiate the dynamics of integrated environmental research, the better equipped we will be to work out how we might achieve a sustainable future.

Acknowledgements

Many people contributed to this study, I regret that I cannot fully acknowledge you all here. I would particularly like to thank my main supervisors David Dumaresq and Gabriele Bammer for their untiring constructive criticisms, reading and re-reading. I would also like to thank my other supervisors Art Shulman and Bob Wasson for their timely and valuable contributions.

My heartfelt thanks go to the participants in the study from the Coastal CRC and the CRC for Greenhouse Accounting, especially Roger Shaw and Ian Noble for their crucial support. I would also like to acknowledge the support of the School for Resources, Environment and Society (ANU), and Land and Water Australia for funding this study.

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