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Research and the integration imperative

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1. Introduction

This book presents recent thinking and practice in integrated resource management, and evidences the strength of the *integration imperative*. To develop integrative resource management regimes requires new forms of information and knowledge and thus of research. This chapter explores why integrated research is needed and how it can be progressed.[1] While research and development (R&D) is the focus, the chapter also addresses integrated policy and management – to be useful, research for resource management must connect to activities outside research organizations, in policy and management agencies, interest groups and the community.

The chapter proceeds as follows. Part 2 discusses the emergence of 'integration imperative', different motivations and understandings, and challenges presented for research and policy. Part 3 defines dimensions of integration: purposes, approaches and potential contributions. These parts are general in scope whereas Part 4 draws on a case study to explore practical aspects of implementing integrated research, and does so in an intentionally first-hand and active manner. Part 5 proposes a set of principles for integrative and interdisciplinary research.

2. The integration imperative

The following quotes reflect an increasingly perceived imperative for integration. They also reflect the typically broad nature of statements of this imperative and lack of detailed instruction (*emphasis added*).

> 35.9 The scientific and technological means include the following:
> (a) Supporting *new scientific research programmes, including their socio-economic and human aspects*, at the community, national, regional and global levels, to complement and encourage synergies between traditional and conventional scientific knowledge and practices and strengthening *interdisciplinary research* related to environmental degradation and rehabilitation … (UN 1992).

> 103. Improve policy and decision-making at all levels through, inter alia, *improved collaboration between natural and social scientists, and between scientists and policy makers*, including through urgent actions at all levels to:
> (a) Increase the use of scientific and technological knowledge, and *increase the beneficial use of local and indigenous knowledge* in a manner respectful of the holders of that knowledge and consistent with national law;
> (b) Make greater use of *integrated scientific assessments*, risk assessments *and interdisciplinary and intersectoral approaches* ….
> e) Establish partnerships between scientific, public and private institutions, and by *integrating scientists' advice into decision-making bodies* in order to ensure a greater role for science,

[1] The paper draws on and extends Dovers 2005a.

> technology development and engineering sectors.
> (World Summit on Sustainable Development: Plan of Implementation, 4 September 2002).

The imperative for integration stems from recognition of the interdependence of human and natural systems, central to the modern agenda of sustainable development. Within resource management there are longer standing realizations: for example, land degradation demands recognition and coordinated management of ecological, climatic, economic, cultural and institutional elements.

International and national policy and law state the 'policy integration principle' – environmental, social and economic consideration must integrated rather than dealt with piecemeal to advance the social goal of an ecologically sustainable, socially desirable and economically viable future (eg. 1992 Rio Declaration and Agenda 21, 2002 Johannesburg Declaration). That three-way integration defines an intellectual and methodological challenge to develop integrative methods and capacity. The intellectual challenge is extended by the fact that integrative capacity demands sophisticated understanding of interactions between complex, interdependent and often non-linear human and natural systems. So integration has at least two meanings: *integration in research* combining multiple disciplinary perspectives; and *integration in policy making*, connecting agencies, issues and sectors.

As well as in policy and research there is the need for integration of social, ecological and economic factors in practical resource management. Research may inform management and policy settings may constrain or enable it, but the variability of management contexts, needs of land managers (farmers, water catchment officers, foresters, reserve managers, etc) and expertise and knowledge they possess indicate that on-ground management is a further domain of integration. Although widely advocated, how to achieve integration is not well understood in either research or policy. It is important to note a delineation in the intent of integration: *informative*, to inform understanding or to develop policy support tools; or *decisive*, to formulate integrated policy or management decisions.

2.1 Different integration imperatives

The policy integration principle is only one imperative driving integration. To expose others we can consider the characteristics of resource management problems that suggest the requirement for more than one policy sector/agency or one disciplinary response. The problem attributes that render sustainability problems different and difficult suggest multiple drivers for integration (drawing on Dovers 1997):

- *Integration in space*, demanded by natural processes operating over variable and extended spatial scales (eg, whole catchment systems, landscape-wide ecological functions, nutrient cycles). Resource management problems also traverse political, legal and administrative boundaries, requiring at least coordination if not renegotiation of boundaries.
- *Integration in time*, to address extended and variable temporal scales (eg. climate, evolutionary processes, non-degradable wastes, species population viability, etc, versus political or economic time scales), and the often cumulative rather than discrete nature of environmental impacts.
- *Integration within and across academic disciplines, professional domains, and policy/management sectors*, demanded by connectivity between substantive issues (eg. salinity, water quality and vegetation, or catchment management and fisheries) and between policy sectors (eg. public health, environmental protection, industry policy, etc).
- *Integration vertically in social systems, and within and across sectors*, to address 'systemic' causes of environmental degradation, deep within patterns of production and consumption, settlement and governance. This demands attention to indirect causes of problems rather than simply treating symptoms (or corrective *versus* antidotal measures, Boyden 1987).

- *Integration of understanding of natural systems, economic drivers, legal and institutional contexts, and social and psychological factors in policy design and implementation*, driven by the need for innovative policy and management approaches.
- *Integration of different segments of society and their knowledge systems* (firms, governments, civil society, Indigenous cultures, research institutions), in view of the need to involve many communities in natural resource management and to establish partnerships between private, public and community interests.
- *Communication as integration*, where transfer, wider ownership and uptake of existing, possibly unconnected information can serve to advance integration.

The last two imperatives provide a further arena of integration: *integration through participation*. This is closely related to the other three (research, policy, management) and is no less problematic or imperfect in practice. It also contains different aspects: integration of community into management programs; integration of non-government players into higher-order policy processes; and integration of formal (disciplinary-based) and community or traditional knowledge. Claim to validity by a wider range of knowledge systems is a feature of contemporary sustainability debates. All this suggests different but related aspects of integration, and thus the importance of defining the *purpose* of integration – identifying which of the above problem characteristics are most relevant before selecting the appropriate methods or processes.

2.2 When and when not to integrate

If integration is required, then 'disintegrated' or singular research and policy approaches must have been tried, evaluated and found wanting. If a single-sector policy or single discipline R&D approach is available and not used or has been insufficiently used, attempting the harder task of integration could be an inefficient diversion. Integration and interdisciplinarity are terms in danger of becoming mere passwords in workshops and funding applications. To counter this and ensure rigour and best use of resources, the *problem definition* phase in either policy or research needs to be emphasised, and the need for integration justified by reference to the lack or failure of non-integrated alternatives.

Flowing from this consideration is the recognition of *degrees of integration*. Full integration of environmental, social and economic considerations and the many relevant disciplines is not necessary every time. Partial integration may be appropriate. Additive (not integrative) *multi*-disciplinary R&D may be sufficient, or the partial integration of community representation into a policy process, or input by a social scientist to problem definition and research design in a biophysical science project (or a biophysical scientist into a social research project) but not much in subsequent phases. Similarly, for some policy challenges, modest involvement of another portfolio or agency may be sufficient. In other cases, more substantial and sustained integration may be required and demand substnatial institutional reform.

2.3 Motives and interests in integration

Although early recognition of the need for integration emerged from academic literature and environmental activists the situation is not now so clear. While new, interdisciplinary research programs are the major loci of activity, equally strong calls come from policy and management agencies, and from community stakeholders in resource management who confront inseparable ecological, social and economic issues. While everyone may agree that integration is required, what they mean by integration and what fires their interest will vary. The example of integrated catchment management (ICM) can illustrate. ICM aims to integrate aspects of resource management that were managed through separate agencies, policies and processes. ICM has

widespread currency and been widely implemented, and is an approach still underconstruction. The following characterizes players and motivations in ICM:

- Natural scientists who understand one aspect of the biophysical system (eg. landscape ecology, geomorphology, hydrology), and perceive interconnections in resource management problems and seek to integrate with other disciplines. Aquatic ecologists and hydrologists might address riparian and stream biodiversity as affected by flow regimes, while ecologists work with economists to establish methods for ecosystem valuation.

- Social scientists from various disciplines, driven by intellectual curiosity and research funding, seek ways of incorporating social, cultural, political, legal and economic dimensions into resource management, a field they perceive as dominated by natural science and administrative rationalities. Rural sociologists and environmental psychologists seek to understand landholder understanding of biophysical issues and to integrate these with policy making. Black-letter lawyers explore issues of non-compliance, while law-in-context researchers examine regulatory implementation at finer scales. Economists advance game theory and agent-based modelling to understand land managers' behaviours, multi-criteria analysis to integrate values, and tradeable rights as policy instruments.[2]

- National policy makers, seeking efficiency and effectiveness in program delivery and expenditure of government funds, pursue the development of a generic approach for integrating salinity, water quality and biodiversity, to be implemented at regional or catchment scale through accredited plans.

- State/provincial and local government, seeking to balance resource management objectives with regional development and employment, development of agricultural industries and maintenance of downstream town water quality, emphasising tradeoffs between these imperatives through negotiation processes and coordination between agencies.

- Rural landholders, focused on farm viability and maintenance of the natural resource base, concentrating on involvement in district scale, community-based groups engaged in on-ground management activities, and on financial and taxation assistance to encourage conservation works. They emphasise the need for integrated frameworks for data gathering and recommending land use options.

- A research funding agency tasked with investing in integrative R&D to produce operational strategies, where proposed integrative approaches are contestable and demand exceeds the supply of funding and partnership arrangements with other agencies are difficult to develop.

These variations are defined by a limited range of issues (water quality and quantity, salinity) at a particular scale (the catchment). Other issues relevant to integrated resource management are not suited to research or policy at catchment scale (infrastructure, communications, education, community development, industry policy, public health, etc). Moreover, the weak institutional and statutory base of catchment management in most jurisdictions creates problems in maintaining integrative initiatives and linking catchment management with other policy sectors.

2.4 The magnitude of the integration task

While there are overlaps between these interpretations of integration, motives behind them and the collaborative directions they invite, there are also differences to negotiate among a range of players. The ICM context is relatively well-understood and the preceding indicates that 'integration' in ICM is complex, difficult, full of contested methods and proposed institutional structures. If we widen the scope to all possible contexts of integration – issues other than

[2] The humanities have not been included here although arguably they should be (eg. the role of historical analyses of landscape conditions, human motivations and policy experiences; see Dovers 2000).

catchment management, whole-of-government institutional reform, cross-sectoral policy assessment, global issues, and so on – the task is more difficult.

Integrated resource management will be *significantly more difficult* – intellectually and practically – than non-integrated research, policy and management approaches. That shift comes with the modern idea of sustainability: we have to do both more and better. If the implications of this for intellectual, human, financial and institutional resources are ignored, failures in R&D and policy are inevitable (see Connor and Dovers 2004). Although there have been significant advances in theory and method, and to some extent in policy and institutional reform for integration, the magnitude of the task should be appreciated. Sustainability is a higher-order social goal akin to democracy, justice or equity. Such goals are long term, pervasive, and always contestable in definition and implementation. Over the next few decades, it can be expected that the integration imperative will be continuously addressed and advances made. But it will take time and coordinated efforts, and there will never be a singular approach.

Widely accepted integrative metrics capable of guiding decisions will never exist. At best, integrative R&D and policy processes can *better inform decisions, but not make them*. Integrative approaches will not make political choices redundant, and the contribution of integrative methods to policy and management is to identify and describe connections and inform more sophisticated trade-offs. Only a political decision can incorporate incommensurable information and values.

The above exposes but does not define the many dimensions of integration. This stresses the importance of a framework within which different integrative initiatives can be viewed, to allow understanding and negotiation of these and to inform choices in a complex area.

3. Dimensions of integration

This part presents a categorization of dimensions of the integration imperative. The five dimensions are: why integrate (purpose); how to integrate (methods); participation as integrative strategy; issues of scale; and expertise and integration. Comment is also made on communication and learning.

3.1 Why integrate: definition of problem and purpose

The impetus for integrated research arises from two requirements for sustainability: integrating ecological, social and economic factors; and integrating different interests. This informs the following categorisation of the purposes of integration, as does a differentiation between integration aimed primarily at *informing* policy and management and that which is *decisive* in producing policy options.

1. *Integration of ecological, social and economic factors*, accepting that integrated resource management or sustainable development cannot be significantly advanced while these are considered separately. This has two aspects:
   (1a): To increase understanding of linked phenomena – that is, of interdependencies within and between natural and human systems – whether as desirable knowledge in itself, or driven by a defined policy problem. This involves the integration of existing, separate knowledge and understanding, and the creation of new bodies of knowledge.
   (1b): To inform the design of policy processes, organisational structures and institutional settings to enhance capacities to integrate environmental, social and economic factors.

2. *Implementation of integrated policy and management*, through prescriptions for policy instruments and processes, institutional reform or management interventions. Such prescriptions may emerge from (1) above, and in publicly-funded R&D there may be sensitivities over research that prescribes policy or institutional options.

3. *Integration of differing interests* through community participation and stakeholder involvement in research, policy and management. This reflects the belief that policy and management will be therefore more effective, and the ideal of participatory politics.

Although simplified, this delineation is a first step in understanding some of the complexity of the task, and allows further specifications on *how* and *who* below.

3.2 How to integrate: methods and processes

There are multiple means of addressing these imperatives for integration, and five broad categories are identified below: interdisciplinary research; methodological development; applied problem-solving; policy and institutional design; and communication-as-integration.

Interdisciplinary and multi-disciplinary research and development

Research that combines multiple disciplines is core to understanding linked phenomenon, and to informing policy and management settings. A history of increasing disciplinary specialisations, each with their own 'epistemological commitments' (Schoenberger 2001), theories, methods, data requirements, etc, has allowed penetration of understanding at finer resolutions, but can work against integrated understanding. Single discipline research remains crucial to knowledge generation for resource management, as does *additive* multi-disciplinary R&D not questioning the operating assumptions or methods of contributing disciplines. So does largely single discipline work that incorporates knowledge from another discipline without questioning its source or validity.

Most difficult is interdisciplinary research with *transformative potential* for the participating disciplines. If sustainability problems are different and difficult enough to present serious challenges to existing understanding and policy approaches (eg. Dryzek 1987; Dovers 1997), then there is a *prima facie* case that disciplines and related professional domains, out of which such understanding and approaches have developed, may be deficient. Interdisciplinary research demands exposure and questioning of theory and method, in turn requiring a critical or reflexive capacity within the research process. Such questioning has been a feature of some interdisciplinary activities to date, such as in ecological economics (eg. Common 2003; Dovers et al 2003). Assumptions in neoclassical economic regarding rational utility maximising behaviour and consumer sovereignty have received sustained critical attention. Other disciplines and their assumptions (eg. ecology, law, public policy) have received less scrutiny. The need for transparency and critical evaluation instructs that integration of disciplinary perspectives cannot be an add-on, but must be core to problem definition and research design.

The contribution of different disciplines depends on the problem at hand. Some disciplines have been prominent in 'integrative' endeavours, such as economics, rural sociology, hydrology and ecology. Others have been less prominent. The optimal combination of disciplines cannot be prescribed without reference to the key variables and processes operating in a given context. Similarly, the appropriate style and degree of integration will vary. It may be sufficient for, say, a lawyer or economist to be briefly involved in the problem-framing and research design of a biophysical project so as to ensure relevance to the regulatory or incentive setting. Alternatively, sustained involvement of a larger number of disciplines may be required, generating new theoretical propositions, methods and insights.

Some disciplines have a history of interaction and work together more easily. Some, such as ecology, geography and public policy, are already methodologically and theoretically diverse. Natural scientists might connect more easily with other scientists than with qualitative social scientists, and vice versa. Connections across major disciplinary divides – social and natural sciences, the humanities – might be expected to be more difficult to achieve. But it is across those divides where sustainability-oriented 'interdisciplines' have developed, such as environmental history and ecological economics (Pawson and Dovers 2003; Dovers et al 2003).

Key differences between disciplines must be identified and reconciled for effective interdisciplinary interaction. A survey of these is not possible here but some deserve mention. One is the spatial and temporal scales implicit in theory and method. Another is whether approaches to natural systems assume deterministic, linear *versus* non-linear, stochastic processes. Some disciplines favour whole-system approaches, whereas others more naturally embrace reductionism. Assumptions about the motivations for human behaviour vary, as does awareness of the social construction of knowledge.

Two other differences deserve note. One is the degree to which disciplines are policy-oriented, and thus the contribution they can make to policy-oriented research. Disciplines such as economics, public policy and law are closely oriented to policy, whereas most natural sciences and some social sciences and humanities (eg. psychology, history) are much less so: it is not their topic. There is a tension here. Policy-oriented disciplines may be expected to have more to say about policy. But if existing policy processes and instruments are deficient, as many concerned with sustainability believe, then the explanations of traditional economics, law or public policy (for example) might lack purchase. The second is the quantitative-qualitative divide where, at the extremes, quantitative researchers cannot accept 'rigour-without-numbers', but are in turn are suspected of assuming away reality to allow mathematical neatness. Away from these extremes remain problems of reconciling methods, data sources, and modes of analysis. Such deeper differences must be explored before practical issues of interdisciplinary interaction are negotiated.

We should also recognise *intra-disciplinary variation* – theory and method are not uniform within disciplines. For example, the sub-disciplines of resource and environmental economics generally utilise neo-classical assumptions and methods, whereas ecological economists or institutional economists may not. Empirical ecologists will define problems and design analysis differently to ecosystem theorists. Black letter lawyers approach questions differently than sociologists of law. And so on. The choice of collaborator from another discipline is a critical decision as it will influence theoretical assumptions, problem definition, methods, data requirements and findings.

Methodological development, and applied problem-solving.

Interdisciplinary research may seek to enhance understanding, but just as commonly – and often in concert with agencies or stakeholder groups – the aim will to develop analytical methods and decision or policy-support techniques. At times, R&D may involve not only development of techniques but also apply them to actual problems. The distinction between the two may be blurred, however it is an important distinction to be aware of as it raises questions of the role of research, the difference between research and consultancy, and of responsibilities and liabilities within the policy system. The inevitably political nature of policy processes and decisions makes this more complicated than the better understood continuum of basic-applied research.

There are far too many actual or potentially integrative methods to cover here, so illustrative examples will suffice. Some methodological development involves extension of existing approaches, such as with extended cost-benefit analysis incorporating non-market valuation, or satellite physical resource accounts appended to national economic accounts. Historians and natural scientists, separately or in combination, may seek to meld documentary, oral and scientific information to establish previous vegetation patterns or river condition. Some methodological development may stem from a questioning of the appropriateness of merely adapting existing approaches. Examples are multi-criteria analyses (MCA) not reliant on monetary valuation, or integrated 'green accounting' as a deeper (highly contested) integrative strategy to correct perceived deficiencies in the national accounts. All such approaches have variations and can be used in either informative or decisive modes. For example, MCA may integrate factors toward a single option or be used in a heuristic fashion to assist but not instruct decision makers. Some approaches are particular to one set of users, such as 'triple bottom line'

accounting, which seeks to operationalise the policy integration principle in the operations of private firms.

There is a critical link between methods and deeper interdisciplinary interaction. Integrative methods can be utilised without shared understanding of the assumptions and theoretical propositions that underpin method, and the limits or qualifications those might entail. For example, contingent valuation, a non-market valuation technique, may be used in an integrative assessment project, with the participating scientists or managers being unaware of contests over its underlying assumptions (eg. reliance on willingness-to-pay rather than willingness-to-avoid, Knetsch 2003). Any integration program or initiative should seek to make all proposals methodologically explicit and to encourage exposure of the assumptions that underlie methods.

Policy processes, organisational structures and institutional settings

The third broad means of integration is the creation of policy processes, institutional settings and organisational structures to achieve integration of environmental, social and economic factors. Traditional divisions across portfolios and agencies can impede integration. Again, disciplinary or interdisciplinary research may inform such design, likely through a smaller range of policy-oriented disciplines.

Many policy, organisational and institutional remedies to fragmentation exist or have been proposed, and again only illustrative examples are given here. Approaches such as strategic environmental assessment or sustainability assessment aim to embed environmental concerns into the policy process across different sectors, significantly extending the scope and impact of the tradition of more limited project-based environmental impact assessment. Environmental officers in non-environmental agencies (eg. defence, water supply, etc) serve a similar aim at a more operational management level. Placing production and conservation functions within one portfolio rather than separate ones (eg. a department of conservation and agriculture) is an integrative strategy tried in many jurisdictions. ICM is an integrative organisational reform. Cross-sectoral policy (eg. oceans, biodiversity) addresses integration as does legislation imposing responsibilities for such issues. Whole-of-government integrative strategies include offices or commissioners for environment or sustainability in some jurisdictions, or environmental sub-committees of Cabinet. Many countries have established a multi-stakeholder national council for sustainable development to promote coordination and integration.

Communication-as-integration

Communication represents an integrative strategy, either in and of itself, or as a necessary co-element with other strategies. On the first possibility, separate disciplines, professions and policy sectors have limited understanding of theory, methods or data in other domains and straightforward communication may advance integration. Second, communication is necessary to the success of other integrative strategies: interdisciplinary research, methodological development and implementation, participation, and policy and institutional change. All these involve new groupings of people and new flows of information and knowledge.

3.3 Integration through participation

The modern idea of sustainability places as much emphasis on community participation as it does on environmental-social-economic integration. Indeed the two principles are related. Participation-as-integration also requires differentiation of ends and means. This issue is merely noted here, with the following purposes and forms of participation listed as examples:

- To integrate community perspectives into policy debate and formulation, via inquiries, inclusive policy processes, deliberative research methods, representative membership of advisory committees, etc (Munton 2002).

- To integrate community members into policy and management implementation or monitoring and evaluation, via mechanisms such as community-based land management groups, honorary rangers or similar positions, co-management arrangements, etc.

- To integrate local or specific cultural knowledge with formal scientific knowledge, involving two-way flows of knowledge between community and formal knowledge systems, or collaborative (*participatory*) research.

There is a tendency to conflate participatory and interdisciplinary research, and while they may overlap the distinction should be maintained for clarity. An economist and ecologist may collaborate to develop an integrative method for addressing conflicts between conservation and agricultural production – interdisciplinary, but not participatory. An ecologist might undertake research on remnant vegetation in partnership with local landholders – participatory, but not interdisciplinary. Participation does not equal participatory research unless the contributed knowledge brought to the process by those participating (eg. landholders, Indigenous owners) is treated as a valid knowledge system.

3.4 Who integrates: roles and skills

Many disciplines, interdisciplinary enterprises, professions and parts of the wider community have the ability or potential to contribute to integration in resource management. Who can contribute what to a specific process or project will vary according to the problem at hand, emphasising the importance of the problem definition phase and of a problem focus in integration. To illustrate, we can consider the broad stages of a policy process and the formal disciplines of relevance. These stages are problem framing, policy framing, policy implementation, and implementation and monitoring (Dovers 2005b). In the first stage, the focus can be on negotiation of broad social goals (inviting the contribution of political science, history, demography, philosophy, etc) or more on environmental change (inviting ecology, atmospheric chemistry, hydrology, etc). In policy framing and implementation, disciplines such as public administration and law have particular roles. In the final stage, where policy is evaluated and where policy monitoring and environmental monitoring must be linked, there is a role for a wide range of natural and social sciences. Taking a complete view of the policy process forces recognition of the need for at least multidisciplinary and probably interdisciplinary R&D. As well as formal disciplines, a wide array of interests and other knowledge systems throughout the community are relevant throughout the policy process.

A crucial factor in problem definition in the research process, and thus of who contributes to a research project, is that often a single individual or limited group defines the problem and then seeks support and involvement. Without an unusually wide grasp of many disciplines, the problem definition and thus inputs to the R&D process may be constrained.

3.5 Scale and integration

To understand and manage linked environmental, social and economic systems, integrated research must deal with interactions across multiple spatial and temporal scales. Some elements of this are well appreciated, such as disjunctions between political and ecological or hydrological boundaries or between temporal scales over which ecological, political and economic processes operate. Such disjunctions represent research as well as practical policy and management challenges.

In interdisciplinary research this issue can be subtle, as scales are embedded in the theory and method of different disciplines. Like much about disciplines, this may involve assumptions and determine method and data in ways not apparent to those outside and even taken for granted within. For example, the spatial scale of the law is defined by jurisdiction, for anthropology it may be culturally or ethnically determined, for hydrology by watersheds, and for economics by individuals, firms, national economies and trading systems. The temporal scale of the law is

determined by the enactment of statute law or by common law precedent, for ecologists in a range of ways, and differently again for historians. As with other disciplinary features, the task is to seek clarity in problem definition and research design stages through justification of the chosen scale with reference to the problem at hand, and of problems with transferring information or findings across scales.

3.6 Interconnections and learning

Categorisations such as the preceding recognise multiple meanings the term 'integration' which is often used as if it has unitary meaning. A finer resolution understanding is essential to efficient and effective research and policy, however there are blurred boundaries and interconnections between dimensions of integration as important as the separation of them. For example, different purposes may be interrelated. Integrated research to deepen understanding of linked phenomena can inform policy design to manage such phenomena, if the potential is designed into the research approach. Similarly, theoretical inquiry may be a necessary precursor to methodological development.

The benefits of recognising interconnections include the potential efficiency of achieving multiple objectives through single investments, and a reduced likelihood of poor outcomes through incorrect problem framing. It is easy but insufficient to claim the general relevance of integrative research to resource management. It is necessary to specify precisely how the connection can be achieved, whether through research design or communication.

Given the differing purposes and forms of integration, numerous individuals and organisations will be engaged in a fragmented experiment over many years. It can be expected to be difficult to maintain coherent directions and shared awareness of theoretical, methodological and practical developments. This suggests that coordination and communication will be important.

4. Practicalities and people: managing integrated research

At this point this chapter changes tone, and seeks to both ground and bring to life to the discussion thus far, which has been general, using hypothetical or typical examples, aimed at clarifying key terms and concepts and drawing attention to their implications. This part addresses the realities of managing integrated research when it involves multiple interests and forms of integration. A case study is used, of a long running and successful R&D program, supplemented by peronalised insights into the reality of integrative research in a human landscape.

The theory of integration is complex, but the practice of integration is frustrating, time consuming, costly and publicly degrading. Possibly for the very same reasons, it is also exciting, rewarding and ultimately worthwhile. The experience of one of Australia's environmental research funding bodies, Land & Water Australia, demonstrates that integration is both a necessary evil and a kindly matron. Ultimately, which prevails comes down to managing relationships, at both the institutional and personal levels.

In 1992, managers within Land & Water Australia perceived the need to address dryland salinity across different jurisdictions, disciplines and geographic localities in a single, integrated research program. The National Dryland Salinity Program (NDSP) was created, with a wide range of federal, state, industry and research partners.[3] Analysis of previous failures to deal adequately with this growing national threat showed that the essential knowledge generation

[3] Richard Price managed the NDSP for 11 years. For a synthesis of the activities and products of the program, see Robins (2004), and for an analysis of another integrative program see Price (2003). This account draws on this close personal involvement.

efforts were institutionally and geographically disparate and largely in competition against each other for limited research funds. Remote sensing techniques, for example, would be researched in one catchment, landscape modeling in another, agronomic solutions in yet another while economic and social research hardly got a look in.

With the NDSP was born the idea of using focus catchments to provide foci for scientific integration, while at the same time enabling local stakeholders to participate in the management of research and in its conduct. Five catchments across Australia were selected (on grounds that were more about politics and equity than science). Lessons learned from this process included:

Problem definition: Everyone has a different perspective about what the problem is, and in many cases, those who 'see the big picture' see a very different big picture. For example, in a NDSP workshop, a bureaucrat painted his big picture based on how catchment management fitted into a broad, macro policy setting. A catchment manager showed how policy was only one perspective within a big, diverse view of community relationships. A researcher, newly acquainted with emerging tools to integrate economic, social and biophysical data, argued that policies, relationships and 'hard facts' could indeed be quantified and structured within complex systems models from which good policies and practices would flow. And finally, a farmer simply said, "This is the big picture: I've got to eat, got to pay bills, got to educate the kids, got to replace the machinery, got to second guess God about the weather and got to look after not just the farm, but the catchment and the rest of the country too!" Bringing different perspectives to bear on a problem, and recognizing the differences in perspectives is critical.

Collaboration: Getting groups to agree to a definition of a problem is difficult, but getting agreement to collaborate is even harder. Collaboration meant for many NDSP partners having to find and allocate resources, convincing hierarchies about the importance of a partnership, and agreeing that not every agency can be the 'lead' agency. While consensus was reached about a common NDSP goal, it had to be recognised that this goal was not always fully consistent with the goals of the individual collaborators. "What's in it for us?" was a more common thought than "How can we contribute?". A legal framework establishing a framework for the collaboration, including specifying management and intellectual property arrangements, enabled institutional processes to interfere less with the research processes. Without collaboration at the management level, it is hard to create an environment for integration at the research level.

Integration frameworks: Over ten years the NDSP trialed several frameworks for integrating different research knowledge. Modeling proved an expensive challenge – Do we build a new model or refine or drastically alter existing ones? One-dimensional or two? One based on understanding processes, or one providing management options? It seemed every researcher was married to a particular model. All variations were supported. In the eleventh and final year of the program, the most effective model for integration was found – three separate manuals for three different audiences. The manuals provided a rallying point, and the process of developing the manuals relied on team work and synthesis. Debates had timelines – the publication date! The beauty of the manuals was that they posed questions for researchers to answer, but in a way no one discipline could answer satisfactorily. The answer here to the integration of science was to get close to the demand perspective.

Resources: Interdisciplinary research is costly, especially if modeling requires field-based data collection and validation. Taking into account social, environmental and economic factors required investment in research not traditionally supported in, but critical to, salinity management. Costs of additional meetings, workshops and working on 'other people's territory' (especially where this was far from home-base) meant enormous strains on time and budget, but proved an irreplaceable means of getting integration to occur face-to-face. Interaction, communication and coordination are an investment in integration, not a cost.

Pooling: Pooling resources is more than a gesture of goodwill. The funding model for the NDSP evolved over time, but was most effective when different organisations were able to pool

resources into a common funding account. This also meant pooling management and technical expertise to ensure accountability for the expenditure and allocation of pooled funds and the rigor of the science undertaken. Placing one's resources into the trust of a collective is a starting point for breaking down barriers between institutions and disciplines.

Conflicting masters: Researchers involved in integrative research are inevitably placed into an arena of conflict. The NDSP supported over 50 projects, each of which was not only associated with the NDSP, but also with one or more programs of partner organisations. For example, a catchment characterisation project supported by the NDSP was also supported under a partner's basin strategy program, another partner's state salinity program, and another partner's hydrology program. Where activities were embedded in ongoing programs of collaborating partners, these activities were conducted within an environment of conflicting infrastructures, agendas and hierarchical allegiances. This required support by respective management interests to enhance researchers' capacity to navigate complex institutional boundaries. In many cases, however, researchers could see what needed doing, with whom research was best shared, and then just got on with it, sometimes totally under the radar screen of management.

Information Management: The NDSP included a technical committee that helped to ensure common approaches and protocols were used across projects to assist the integration of information. The committee was largely free from undertaking research in the program, but had very close association with it. Because it had a role to direct what research was undertaken, and how, it was able to influence the degree to which integration took place. For example, a catchment characterisation system that was developed to map regional groundwater flows was directed by the committee to be accepted as the basis for underpinning projects as diverse as engineering, economic cost analyses, saltland production and local government policy. A well-respected guiding hand can play a large role in facilitating integration across institutions, disciplines and regions.

Timeframes: Integrated research will always take longer than planned. In the case of one highly complex catchment modeling project, which had a life of five years granted to it on the basis that the establishment might take time, getting agreement to the conceptual framework took over two years. This time was needed to develop team ownership, shared understanding, team trust and something resembling a common language. The project did not finish on time, and was better for it. Investing time to build relationships needs to be a legitimate part of the research process.

Communication: Here is where it starts and ends. The most powerful tool of the NDSP was its communication network. This operated at several levels: among management, among technical and communication specialists, among stakeholders and most importantly between each of these groups. One quarter of the NDSP's budget was dedicated to communication. People learned from sharing experiences. Communication materials were developed with different users in mind. Researchers liked to share information with other researchers, and didn't mind at all knowing what was going on in other disciplines dealing with the same substantive issue. Farmers liked to share their success stories with other farmers, and liked to get a comment or two from researchers as to why something they were doing actually worked. Communication was facilitated through print, websites, list-servers, workshops and conferences. Letting people ask questions and demand answers stimulated more integration than any model.

The case of the NDSP indicates the realities of practice that exist beneath the different kinds of integration defined earlier in the chapter. The following personalised reflection, by the program manager Richard Price, is a more direct, plain language insight into the activities that happen under an initiative such as the NDSP – it is important to remember that researchers and stakeholders are human and behave as individual humans, not as either theory or method instructs or expects them to.

I will never forget my five-year association with the Liverpool Plains of northern New South Wales. One moment it was a backwater of the state, with the biggest research problem being "To till, or not to till?" Suddenly salinity was the big issue, with the major problem being soil compaction from every researcher and his dog wanting to tread all over the farm paddocks in the district. In one foul swoop, the Liverpool Plains had become a research focus catchment. Participatory research, interdisciplinary research and multi-organisational research were the order of the day! "Here is where the money is at!," said the funding bodies. "Then that's where we will go," said the research agencies.

The major project had a title like "Integrated catchment modelling to support community decisions in the Liverpool Plains." Eight major research organisations, including four federal, two state and two university groups were involved. All up, 35 researchers covering fields such as soil science, hydrology, economics, systems modelling, plant physiology, geology, remote sensing and the like were involved. One organisation had been given the contract on behalf of a research consortium and was expected to coordinate all the others.

At first, no-one objected to coming on board of such a complex project. For some organisations, collaborative projects meant attracting further resources into the organisation. Indeed, for these organisations it was the only way to attract resources - collaborate or perish! Salinity is a complex issue, and it seemed just common sense to work across disciplines in the one region.

I wondered, however, if we were overcomplicating something that perhaps had no possible solution – that if we threw enough disciplines at the problem it would just go away. Still, it was good form to collaborate, and meant that you were open to new ideas. This project offered to assemble some of the best minds in the salinity game, and bring their combined wisdom to bear on what we thought was a relatively simple catchment.

However, dealing with so many institutions and disciplines had its downside. Arguments proliferated about resource distribution, which models to use, who should report to who and which hierarchy to follow. We also had to take care to recognise whose territory we were on at any point in time. Egos ran rampant. Voices were raised. Tempers flared. Researchers were at it hammer and tongs. This was science at its best! And things would have run well enough too, except that this was also supposed to be a *participatory* research project. The debates we had, the fine detail we fought over and the language we struggled with all took place in community halls and on farmers' paddocks. No wonder the community was frustrated, looking on in astonishment at the intrinsic messiness of interdisciplinary research. What was normal for us looked totally unruly to them. Indeed, it was unacceptable and they told us as much.

But on reflection, it wasn't normal for us. We were struggling with the notion of interdisciplinary science at the same time we were struggling with the notion of participatory research. The complexity of integration had increased exponentially. I realised there were so many of us, having so many arguments, because we were responding to a community with so

many different perspectives. We learnt quickly that there is no one community, with only one perspective, and that realisation ultimately became the major research challenge. And above all, we learnt quickly that we are all amateurs when it comes to integrated research.

The project progressed over the years through paths rocky, turns unexpected and pit-stops unplanned. It took over two years before the research team was relatively comfortable with one another. Suspicions about each other's motives had dissipated. The community was posing questions that meant something to all of us, even though it meant something different to each. We had a basis to work from, and by the time we had agreed upon a conceptual framework, it came as a hard blow to be told that we had finally reached the starting blocks and not the end point. Still, a sense of camaraderie had developed from our shared trials and tribulations, and the remainder of the project ran smoothly.

It became apparent over the years that we were beginning to work in a very crowded territory. What was novel at the beginning of the project was coming more commonplace by the end. The managerialists of the world had taken control of the boardrooms, and every organisation was expected to deliver not just outputs, such as new technologies, but also deliver outcomes – evidence that clients were using the technologies. This was great in theory, but it meant that every organisation was seeking changes in client's practice, and so every institution started to develop its own communication capacity, each trying to engage the same clients. Also, everyone wanted to take the lead in playing the role of coordinator, so they could be seen to be the one driving the outcomes. It didn't seem to matter if the research group was a university or a government regulatory body with a research arm. More and more resources of different agencies seemed to be going into dealing with the same stakeholder, and less seemed to be going into research.

I was wondering if we had lost sight of vertical integration between research institutions in wanderlust of horizontal integration with the community. Ironically, are we becoming less efficient in the use of limited research funds, and as a result providing less value to the very community we serve?

That reflection portrays the sort of reality often missing from articles advocating integrative research for resource management, or reporting positively on only the findings of an integrative program. We now turn to a set of principles for integrative and/or interdisciplinary research, which although well-based on theory and evidence also convey some of that difficult reality.

5. Conclusion: guiding principles for integrated research

There is no single path to integration, because there are multiple purposes and forms of integration. Design of integrated research needs to be guided by principles that reflect this complexity. The following extends the 'essential elements of interdisciplinarity' proposed by Barnett et al (2003), as a set of principles which brings together the discussions in this chapter:

- *A problem focus*, whether applied, theoretical or methodological. Without a clearly defined problem, integrated research can only succeed through luck, and explicit problem definition encourages early consideration of the skills and perspectives required.
- But also wariness of *the dangers of capture* by singular or partial policy objectives. Sustainability is a long-term problem pervaded by uncertainty, dealing with non-linear systems, and integrative research should not be driven solely by immediate agency agendas.
- A *critical, reflexive capacity*, including recognition of normative content of claims to knowledge. Given the magnitude of the task and the uncertainties inherent in it, sharp and constant evaluation of integrative initiatives is required. However, to not descend into a non-constructive relativism, this critical stance needs to be informed by ecological, economic and political realism.
- *Openness to other disciplines*, theory, method and arenas of inquiry, and to cognate policy sectors, and to knowledge systems other than formal disciplines (lay, professional, Indigenous, etc).
- A *systems orientation*, appreciating the whole rather than only parts and encompassing both quantitative and qualitative constructions of systems. Essential to this is appreciation of key systems properties such as feedbacks, path dependency, thresholds and time lags.
- A close appreciation of *multiple and dynamic spatial and temporal scales*, including a capacity to account for historical determinants of modern situations.
- Appreciation of the *personal/group qualities* required for interdisciplinary work, and the balance of risks and rewards in crossing disciplinary and other boundaries. Previous patterns of interaction, incentive or reward are unlikely to be suitable, whether in research institutions, policy agencies, community groups or private firms.
- The need to *recognise multiple purposes of integration* (understanding linked phenomena, informing policy and management, implementing policy and management; participation) and of recognising potential interconnections and synergies between integrative projects driven by different purposes.
- Close connection between *problem definition and the varying contributions of different disciplines* and other knowledge systems, to apply specific mixes of skills and understanding to specific problems.
- Recognition of *intra-disciplinary variation*, given significant differences in implicit scale, problem definition, theory, method and data requirements within as well as between disciplines.
- Recognising *communication as central to integration*, in terms of communicating new integrative outcomes to potential users, and of encouraging integration through communication of specialised perspectives to new audiences.

These principles are generic but operational enough for translation to specific contexts. They may render integration more problematic, which is consistent with the reality that integrative research, policy and management are significantly more difficult and complex than non-integrated approaches, demanding that we do both more and better as well as differently.

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