

# The Integration Imperative in Natural Resource Management

**Dr Stephen Dovers**

*Senior Fellow  
Centre for Resource and Environmental Studies  
The Australian National University  
Canberra 0200 Australia.*

## **Summary**

This paper discusses the need and means for integration in research and development for natural resource management. It was commissioned in 2002 by Land & Water Australia to inform its activities in this area, and subsequently revised. The imperative for integration of environmental, social and economic considerations in research, policy and management, and for integration of stakeholder interests, is widely recognised as core to the agenda of sustainable development. However, the meaning of integration is often unclear, and existing initiatives are scattered and largely uncoordinated. While the imperative is clear, the challenges it presents are highly difficult and define a long term, ongoing task. This paper seeks to clarify the different dimensions of integration and interdisciplinarity, as an important preliminary step toward advancing mutual understanding and the development of techniques and approaches. The paper identifies the driving forces for integration, discusses when integration is required and when it is not, categorises different forms of integration, and proposes a set of principles to inform integrated R&D.

## **RATIONALE**

It is widely perceived that ‘integrative’ approaches are required to address issues of ecologically sustainable development (ESD) and sustainable natural resource management (NRM). Reference is regularly made to integration in institutional systems and organisations, in policy and management interventions and regimes, and in research and development (R&D).<sup>1</sup> However, there is little apparent consensus over how to ‘do’ integration, and at a deeper level over what integration actually means, or when and why it should be pursued. This should not surprise, as the ‘integration imperative’ inherent in the modern idea of sustainability has only emerged recently, and has profound implications for research and policy.

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1. The term R&D is used here to refer to both pure and applied research.



To inform future investment and activities in integrative R&D, and integration within its own organisational domain, this paper develops a broad framework aimed at clarifying three questions: *what* we mean by integration; *why* and *when* is it needed; and, only then, *how* and *by whom* it might be undertaken or encouraged.

Part 2 notes major claims for integration, viewed against the characteristics of ESD problems, and comments on the current state-of-play regarding integrative policy and R&D. Part 3 delves deeper into the different purposes and kinds of integration, to allow a more operational and finer resolution view of the ‘integration imperative’. Part 4 proposes some guiding principles, and Part 5 concludes the paper.

More attention is focused on the question of ‘why’ pursue integration (ie. the purpose), particularly through emphasising the need for a problem-oriented approach to integration, whether the problem be theoretical, methodological, or applied. This is because, without a clear idea of the purpose of integration—through careful problem definition—as the initial, crucial step, all that follows is likely to be deficient, or at least mysterious to the outside observer or reader. Due to the fact that this paper cannot contain a catalogue of the many actual or proposed integrative methods and processes in a large and burgeoning field, less detail is given on the aspect of ‘how’ to integrate.

## THE INTEGRATION IMPERATIVE

The following quotes, from international and Australian documents, reflect an increasingly perceived imperative for integration. They also reflect the typically broad nature of statements of this imperative and the lack of detailed instruction.

*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, technology development and engineering sectors.*
- (World Summit on Sustainable Development: Plan of Implementation, advance unedited text, 4 September 2002).*

*There are five specific difficulties confronting the institutions involved in environmental management ...*

- *varying regulatory arrangements applied to different land uses in adjacent areas making it difficult to achieve conservation on a landscape scale*
- *responsibilities that are fragmented within and between levels of government and various agencies*
- *different philosophies and approaches between non-Indigenous and Indigenous environmental managers*
- *fewer resources to ensure compliance with government legislation, policy and regulation*
- *limited cooperation between public and private sectors in long-term environmental management.* (ASEC 2001)

*Recommendation 4. To facilitate integrated social, economic and environmental planning and management Australia needs to develop and implement an agreed approach to resource accounting, applicable at regional through Australia wide scales, incorporating market and unpriced values, together with the costs and benefits of resource use (NLWRA 2002).*

The global pronouncements above are broad and open up wide possibilities. Four of the five judgements in the third quote, from Australia's latest state of environment report, identify issues of integration or coordination. The second Australian quote specifies only one particular method among many, natural resource accounting, as an avenue to better decision making. The four quotes evidence different purposes and approaches—such variations are a theme of this paper.

The imperative for integration stems directly from recognition on the interdependence of human and natural systems and sub-systems, expressed in the modern research and policy agenda of sustainable development or, in Australia, ESD. Within subsets of the ESD field there are similar and more widespread realisations—for example, land degradation issues (eg. acidification, salinity, rangeland forage decline, etc) demand the recognition and coordinated management of ecological, climatic, economic, cultural and institutional elements.

International and national policy and law state the 'policy integration principle'. This is that environmental, social and economic consideration must be considered in an integrated rather than piecemeal fashion to advance the higher-order social goal of an ecologically sustainable, socially desirable and economically viable future (eg. 1992 Rio Declaration and Agenda 21, 2002 Johannesburg Declaration, 1992 National Strategy for ESD, *Environment Protection and Biodiversity Conservation Act* 1999 and over 120 other Australian statutes). The integration of environmental, social and economic considerations in policy is an operational challenge that of course defines an intellectual and methodological challenge, to develop methods, processes, data streams and so on to create integrative capacity. The intellectual challenge is extended by the realisation—only recent in historical terms (ie. two decades or so)—that development of integrative capacity demands a much more sophisticated understanding of the interactions between highly complex, often non-linear and very often closely interdependent human and natural systems and subsystems. So, integration has at least two meanings: *integration in research* aimed at combining multiple disciplinary perspectives; and *integration in policy making*, cutting across previously disparate agencies, issues and sectors.

Of course, as well as integration in policy and in research, there is the need for integration of social, ecological and economic factors in on-ground land management. While research may inform such management and policy setting constrain or enable such management, the variability of management contexts, the needs of land managers (farmers, water catchment officers, foresters, reserve managers, etc) and the existence of particular expertise and knowledge by land managers indicate that on-ground management, and its relationship to integrative R&D and policy settings, is another, crucial dimension of integration.

Although widely stated and advocated, precisely how to achieve this integration is not yet well understood, either in research or in policy processes and decision making. It is important to note this major cleavage in the immediate intent of any integration exercise: *informative*, being to inform understanding or to develop policy support tools; or *decisive*, being to formulate integrated policy or management directions. While the two are closely related, the distinction at times may be important to make given the sensitivity associated with supporting or undertaking publicly-funded research perceived as *formulating* policy rather than simply informing that process.

### Different integration imperatives

The policy integration principle is only one—albeit critical—aspect of integration in the context of sustainability, even when extended into the intellectual realm. To expose these other aspects, it is useful to consider the characteristics of ESD problems that suggest the requirement for more than single policy sector/agency or single disciplinary responses. Amongst the problem attributes that render sustainability problems different and difficult are those suggesting a number of drivers for integration (drawing on Dovers 1997):

- *Integration in space*, demanded by the fact that critical natural system processes that operate and must be managed over variable and often extended spatial scales (eg, whole catchment systems, landscape-wide ecological functions, nutrient cycles). As well, ESD and NRM problems cut across political, legal and administrative boundaries, requiring at least coordination if not integration or 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 requires correction of indirect causes of unsustainable behaviours rather than simply treating symptoms; that is, corrective *versus* antidotal measures, such as refashioning the legal and economic

incentives that encourage an unsustainable land management practice rather than simply banning it. ('Vertically in social systems' refers to consideration of not only resource production systems, but all stages from resource extraction through transport, transformation and consumption through to waste disposal, involving not only primary producers and regulators.)

- *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 new, innovative policy approaches (a need in turn driven by perceived or actual failure of previous policy approaches, such as superficial regulatory and educative instruments).<sup>2</sup>
- *Integration of different segments of society and their knowledge system* (firms, government, civil society, Indigenous cultures, research institutions), in view of the need to involve traditional and local communities in natural resource management, and more broadly to establish partnerships between the private, public and community sectors.
- *Communication as integration*, where transfer, wider ownership and uptake of existing, possibly disparate information can serve to advance integration in any of the above forms.

The last two imperatives provide a third, major arena of integration additional to policy integration and interdisciplinary activity: *integration through participation*. This is closely related to the other three (in research, policy and management) and is no less problematic or imperfect in practice. It also conceals quite different dimensions: integration of community into management programs (at varying levels of responsibility and empowerment); integration of non-government players into the policy formulation process at higher levels; and the most difficult of all, the integration of formal (disciplinary-based) and lay, community or traditional knowledge. This widening of claims to validity by a wider range of *knowledge systems* (or 'epistemic communities') is at once a liberating and supremely difficult feature of contemporary sustainability debates.

All this suggests quite different but nonetheless at times closely related aspects of the integration imperative. This in turn suggests the importance of defining the purpose of integration—which of the above problem characteristics are most relevant in a given time and place—from which then can be decided the actual methods or processes suited to the task. The kinds of integration are dealt with in Part 3.

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2. It is important, but unfortunately rare, for claims of past policy failure to establish whether a particular policy approach was inappropriate *per se*, or whether it was poorly designed, implemented or enforced. This applies particularly to regulatory instruments, and is largely unanswerable due to a chronic lack of policy monitoring and evaluation. Arguably, this regrettable situation is also the case with community-based approaches, and will certainly apply in the near future to the performance of market-based instruments. While poor policy monitoring and evaluation is one of the most crucial issues in Australian NRM, this is not taken further here, but see Dovers 2001.

## When and when not to integrate

It should not be assumed that an integrative approach is always needed for progress on ESD or NRM problems. If an integrative approach is deemed to be required, then it must be the case that 'disintegrated' or singular research and policy approaches have been tried, properly evaluated, and found inadequate. If a single-sector policy approach or single discipline R&D approach is indeed available and is not used, or has been insufficiently used, then attempting the harder task of an integrated R&D or policy approach will likely be both inefficient and an unnecessary diversion. Integration and interdisciplinarity are terms already in danger of becoming mere passwords at workshops and in funding applications. To counter this danger, and to ensure rigour and best use of available (always scarce) resources, the *problem definition* phase in either policy and management or in research needs to be emphasised, and the need for integration justified by reference to the lack or failure of non-integrated alternatives. Integration cannot be assumed as a self-evident imperative.

Flowing from this consideration is the recognition of *degrees of integration*. Full integration of environmental, social and economic considerations and all the (very many) disciplines that have purchase on them is not necessary every time. Depending on the problem at hand, partial integration may be more appropriate, efficient and effective, whether in the context of a R&D project, program or portfolio. Merely additive (as opposed to integrative) *multi-disciplinary* R&D may be sufficient, as may be partial integration of community representation into a policy process, or input by a social scientist into the initial phases of problem definition and research design in a biophysical R&D project (or a biophysical scientist into a social research project) but not much in subsequent phases. In the case of R&D programs, integration across projects within a program, or between programs, is required where there is a demonstrable reason for connection, not in every or even most cases. The degree of integration within and across programs will vary from case to case. Similarly, for some policy challenges, modest involvement of another portfolio or agency may be sufficient. In other cases, deeper, wider and more sustained patterns of integration may be required.

## Motives and interests in integration

This invites some consideration of who is driving the move toward integration in policy and R&D for sustainability, and of their motives. Although the earliest recognition of the need for integration emerged from the academic literature and to a lesser extent from environmental activists (with some common membership between the two), the situation is not now so clear. While new, interdisciplinary research activities are the locus of much advocacy and actual advances in integration, equally strong calls come from within public policy and management agencies. Even stronger calls come from some community stakeholder leaders in natural resource management who, more directly than anyone, are confronting the inseparability of the ecological, social and economic issues they seek to address.

While everyone may agree that integration is required, and soon, what they mean by integration and what fires their interest may vary significantly. An example can illustrate, from the familiar setting of integrated catchment management (ICM).

ICM intends to integrate different aspects of NRM—vegetation, soils, water, etc—that are obviously closely connected but traditionally had been managed through separate agencies, policies and processes. ICM has widespread currency as an approach, has been widely implemented, continues to grow in practice, and is an approach that no one would say we have yet perfected. The following (convenient and simple) characterisations indicate some players in ICM and what integration might mean to them. (Note: in all the following categories, there will be others who do not believe that integration is particularly important, but they are probably not the audience of this paper).

- Natural scientists, typically having in-depth understanding of one aspect of the biophysical system (eg. landscape ecology, geomorphology, hydrology, limnology). Some natural scientists realise the interconnections that characterise NRM problems and seek to integrate their own areas with others. Aquatic ecologists and hydrologists address riparian and stream biodiversity as affected by flow regimes. Geomorphologists and agronomists address interactions between vegetation condition and salinity recharge. A group of ecologists team up with an economist to establish methods for ecosystem valuation. And so on.
- Social scientists. Driven by intellectual curiosity and the availability of research funding, groups and individuals from various disciplines seek ways of incorporating social, cultural, political, legal and economic dimensions into NRM, a field they perceive as having been driven, insufficiently, by natural science and administrative rationalities in the past. Rural sociologists and environmental psychologists seek to understand landholder and community understanding of biophysical issues and to integrate these with policy making and the analyses of other disciplines. Black-letter lawyers explore issues of non-compliance under state law, while law-in-context researchers examine regulatory implementation at finer scales. Economists variously research and espouse game theory and agent-based modelling to understand land managers' behaviours, multi-criteria analysis to integrate differing expectations and uses, and tradeable rights in water and salinity and biodiversity credit systems.

Amongst both natural and social scientists,<sup>3</sup> there are those with generic or theoretical interests and those with spatially or sectorally specific or applied interests, and those at points between. Another, increasingly important player in this regard is the consultant, whether from the private or research/tertiary education sector.

- Commonwealth policy makers, seeking efficiency and effectiveness in NRM program delivery and expenditure of Commonwealth funds, pursue the development of a generic model for integrating salinity, water quality and biodiversity issues and targets, to be implemented at regional or catchment scale through an accredited planning processes.
- State and local government, seeking to balance NRM objectives in the catchment with regional development and employment issues, development of agricultural export industries and maintenance of downstream water supply and quantity, emphasise tradeoffs between these imperatives through locally-based negotiation

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3. I have not given the humanities a guernsey here, although arguably they should be, cf. the argument for better historical analyses of landscape conditions, human motivations and policy experiences; see various examples in Dovers 2000.

processes, and enhanced coordination between agencies. Organisational settings for ICM are reviewed to further these goals.

- Rural landholders in the catchment, focused on farm viability and maintenance of key elements of the natural resource base, concentrate on involvement in district scale, community-based groups engaged in on-ground management and restoration activities, on organisational settings for ICM, and on gaining financial and taxation assistance to encourage resource conservation works. They emphasise the need for integrated frameworks for data gathering and use, and for recommending land use options.
- Urban residents within the catchment, primarily concerned with regional economic viability, seek ways of reconciling tensions between maintenance of existing rural industries, luring light industrial activities to the urban fringe, and protection of rural and natural areas for tourism amenity.
- An R&D agency faces the task of investing in integrative R&D with high probabilities of producing operational strategies for sustainable NRM, where most proposed integrative approaches are contestable and the demand by proposed projects significantly exceeds the supply of funding, and where partnership arrangements with other agencies remain difficult to develop and maintain.

As well as the ‘usual suspects’ so crudely characterised above, other players with less integrative perspectives may be highly influential, such as a conservation NGO focused on a particular listed wetland downstream, industry group focused on export development, or the tax office which is deciding on rules permitting tax exemption on conservation works.

These variations and more occur within the ICM context, defined as it is by a limited range of substantive issues (largely, water and salt) and a particular scale (the catchment). Other issues relevant to NRM and ESD, and thus to the integration task, are not at all suited to research or policy at the *catchment scale* (infrastructure, regional development, communications, education, community development, transport, industry policy, public health, etc). Moreover, the weak institutional and statutory base of catchment management in most jurisdictions creates problems in implementing and maintaining integrative initiatives, and in linking catchment-defined activities with other policy sectors.

While there are important overlaps between these different interpretations of integration, motives behind them and the collaborative directions they open up, there are also significant differences that need exposure and negotiation if any coordinated effort or efficient progress are to be made.

## The nature of the integration task

The ICM context is arguably the most well-understood and widely-practiced arena of integration in NRM/ESD at this point in time, and the preceding characterisation indicates that ‘integration’ in ICM is complex, difficult, full of contested methods and proposed institutional structures—and definitely needed. Emerging requirements, such as for integrated natural resource management planning strengthen the imperative for integration. If we widen the scope to all possible contexts of integration—issues other

than catchment management, whole-of-government institutional reform, cross-sectoral policy assessment, global issues, and so on—clearly the nature of the task becomes far more difficult to comprehend and progress.

Integration in natural resource management will be *significantly more difficult*—intellectually and practically—than traditional, non-integrated research, policy and management approaches. That profound shift comes with the modern understanding of the sustainability problem: we have to do both more and better. If the implications of this enlargement of the task for intellectual, human, financial and institutional resources are ignored, then failure in both R&D and policy efforts is inevitable (this argument is further expounded in Connor and Dovers 2004).

There are of course many other, extant integrative initiatives in Australia and elsewhere already. Interdisciplinary endeavours such as environmental history and ecological economics operate at both theoretical and applied levels, globally and locally, producing integrative methods. International programs such as the Intergovernmental Panel on Climate Change and International Human Dimensions Program address explicitly integrative agendas. The European Union's recent strategic environmental assessment (SEA) Directive seeks to force integration of environmental considerations into other policy sectors, and legislative provision exists for such assessment in some Australian jurisdictions. The UN's Commission on Sustainable Development cuts across UN areas, and some seventy countries have established a national council for sustainable development or equivalent to drive policy integration and stakeholder communication. None of these, very substantial programs have as yet 'succeeded'—witness criticism of the poor incorporation of social sciences in the IPCC, of the low impact of the CSD within the larger UN system, of the marginal status of most NCSDs, and of the glacially-paced development of the EU SEA directive. Any claim that someone in Australia has the 'answer' to integration indicates either an astounding but hitherto unnoticed intellectual breakthrough, a seriously inflated ego, or a downright wrong claim.

Several Australian state and territory jurisdictions have (very recently) established cross-portfolio mechanisms such as offices of sustainability in first ministers' departments. Numerous variations of government portfolio and agency configurations exist (and have existed) across Australian jurisdictions, often with the at least partial aim of enhancing coordination and integration in a fragmented policy field. Some Cooperative Research Centres pursue integrative research agendas, as do a number of often much longer-standing university centres and departments (eg. at the ANU, Murdoch, Monash, Griffith). Many major, integrative research programs are already in existence, and many have been completed in the past. A number of operational integrative methods have been developed, both as research and policy support tools, and some are noted in the next section.

Although there have been significant advances in theory and method, and to some extent in policy practice and institutional reform for integration, the magnitude of the task should be appreciated. Sustainability, the agenda that created the integration imperative, is a higher-order social goal akin to democracy, justice or equity. Such goals are long term, pervasive, and never rendered uncontestable either in definition or the ways in which we seek to achieve them. Over the next few decades, it can be expected that the

integration imperative will be continuously addressed and many advances made. But it will take time, the coordinated efforts of many groups, and there will never be singular means of integrating environmental, social and economic factors.

Perfectly and widely accepted integrative metrics capable of guiding decisions will never exist. At best, integrative R&D and any actual policy processes that can be realistically envisaged can serve to *inform decisions in a significantly more effective manner, but not make them*. Fantasies that integrative approaches will somehow avoid the necessity for difficult political choices are best suppressed. The potential contribution of integrative methods to policy and management is to identify and describe connections, and allow more sophisticated trade-offs. In Australia, the Resource Assessment Commission from 1989–1993 and the more recent Regional Forest Agreement process are high-profile examples of attempts to integrate environmental, social and economic factors, but also the imperfection of capabilities to do so. They also emphasise that no integrative analysis and inclusive process, no matter how well done, will be uncontested, at least in the foreseeable future. At the end of the day it will only be a political decision that will be capable of incorporating different forms of information and conflicting values.<sup>4</sup>

As well as integration in NRM and ESD, it would pay to recognise activities in other policy and management sectors from which insights may be gained. For example, use of integrative risk-based approaches, and especially application of AS/NZS 4360 (Risk Management) in community contexts, has progressed further in emergency management than in NRM. Other policy sectors facing similar issues as NRM, regarding integration and other matters, include community and regional development and public health. At a minimum, incorporation of commentary and perspectives from such cognate policy sectors may enhance discussions of integration within NRM.

The preceding discussion indicates but does not clearly define multiple purposes and motives for integration, as well as multiple methods and players. This situation stresses the importance of a widely inclusive but reasonably robust framework within which different integrative initiatives can be viewed relative to the broader problem set, to allow understanding and negotiation of these, and to inform choices and allocation of effort in a complex and rapidly evolving area.

## DIMENSIONS OF INTEGRATION

This part presents a framework identifying and delineating different dimensions of the integration imperative. The five dimensions recognised are: why integrate (purpose); how to integrate (methods); participation as integrative strategy; issues of scale; and what groups have what skills to assist with integration. As well, comment is made on interconnections between these, and on issues of communication and learning in the

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4. For discussions regarding the RAC and RFA, see Hamilton 2003; Mobbs 2003; Ashe 2002.

integrative domain. The point of the following exercise is to allow clarity as to the purpose of integration and the pathways toward integration, whether in terms of assessing or undertaking new R&D initiatives, or evaluating past projects and programs.

## Why integrate: definition of problem and purpose

The impetus for integration arises from two widely-accepted requirements for furthering the social goal of sustainability: that of integrating ecological, social and economic factors in policy and management; and of integrating different perspectives and interests in policy and management. This informs the following, general categorisation of the drivers of integration in ESD and NRM, as does a differentiation between integration aimed primarily at *informing* policy and management capacities towards the end of integration, and that which recommends policy or management options.

1. *Integration of ecological, social and economic factors*, accepting that sustainability, or sustainable NRM, cannot be significantly advanced while these three are considered separately. This has two aspects:
  - 1.1. 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.
  - 1.2. To inform the design of policy processes, organisational structures and institutional settings to enhance capabilities in the integration of environmental, social and economic factors.
2. *Implementation of integrated policy and management*, through specific, operational prescriptions for policy instruments and processes, institutional reform or management interventions. While such prescriptions may emerge from (1) above, in the context of publicly-funded R&D there may be sensitivities with research that prescribes policy or institutional options and especially changes to the structure and function of government.
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 more effective with participation, but also the general ideal of more participatory policy and political processes.

It is proposed that, although simplified, this delineation of the different purposes of integration (ie. why integrate) is a first step in understanding some of the complexity of the task, and allows further specifications on *how* and *who* below. Interconnections between these are discussed later.

## How to integrate: methods and processes

There are multiple means of addressing these imperatives for integration, and five broad categories are identified and summarised in this section. These are: interdisciplinary research for increased understanding; methodological development; applied

problem-solving; policy and institutional design; and communication-as-integration. More detailed discussion is given regarding interdisciplinarity, aimed to expose multiple forms and strategies beneath that increasingly used term.

### ***Interdisciplinary and multi-disciplinary research and development***

Research and development that combines multiple disciplinary perspectives is core to understanding linked phenomenon, and to informing policy and management settings for addressing those phenomenon in the cause of sustainable NRM. 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 R&D remains crucial to knowledge generation for ESD, as does purely *additive* multi-disciplinary R&D that does not involve change to the operating assumptions or methods of the contributing disciplines. So does largely single disciplinary R&D that increases its purchase on a problem by incorporating knowledge from another discipline but without questioning the source or validity of that knowledge.

More problematic and more relevant to this discussion is more deeply interdisciplinary research with explicit *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, then, demands exposure and open questioning of theory and method, in turn requiring a critical or reflexive stance as central to the research process. Assumptions about how the world works cannot be left unexamined. Such questioning has been a feature of some interdisciplinary activities to date, such as in ecological economics (eg. Common 1995). For example, assumptions in neoclassical economic regarding rational utility maximising behaviour and consumer sovereignty have received sustained critical attention by non-economists such as psychologists and philosophers. Other disciplines and their assumption sets (eg. ecology, law, public policy), however, have received far less scrutiny in terms of the validity or usefulness with respect to sustainability problems. 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 (potential or actual) contribution of different disciplines varies enormously depending on the problem at hand. With Australian NRM, some disciplines have been more prominent than others in various 'integrative' projects, such as economics, rural sociology, hydrology and ecology (the latter at times tending to be a catch-all for various natural science perspectives). Other, such as public policy, demography, law and psychology, have been less so. The optimal combination of disciplines cannot be prescribed without reference to the specific context and the key variables and processes operating in that 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 primarily biophysical project, so as to ensure relevance of the work to the regulatory or incentive setting. Alternatively, sustained involvement of a larger number of disciplines may be required, generating new

theoretical propositions, innovative methods, and new, integrative insights. The nature of the disciplinary interaction must be determined by, above all else, the nature of the problem being addressed.

It is worth noting that some disciplines (and sub-disciplines, see below) have a history of interaction, and some work more easily together than others. (And, that some ‘disciplines’, such as ecology, geography and public policy, are already to some degree interdisciplinary, in that they are methodologically diverse and borrow from other disciplines.) Generally, natural scientists might be expected to connect more easily, theoretically and methodologically, with other natural scientists than with, say, qualitative social scientists, and vice versa. Connections across the 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 noticeably in recent years. Ecological economics is the most prominent and arguably promising one, although it has been noted that this field is dominated by economists and neo-classical theory, is informed by a very partial contribution from ecology and lacks methodological development (see various contributions in Dovers et al 2003). The ‘naming’ of an interdisciplinary endeavour is no guarantee of integration. Ecology has been adopted most commonly as part of interdisciplinary fields: for example, political ecology, social ecology and the longest-standing one of all, human ecology (Barnett et al 2004). Yet the contribution of that discipline’s (constantly evolving) understanding of the structure and function of ecological systems is not always apparent in all of these fields.

There are key differences between disciplines; some more obvious than others, and these must be identified and reconciled for effective interdisciplinary interaction. A full survey of these is not appropriate (or possible) here, but some deserve mention. One is the spatial and temporal scales implicit in theory and method (see Dovers 2004). Another is whether approaches to natural systems assume deterministic, linear *versus* non-linear, stochastic processes. Some disciplines more readily comprehend whole-system approaches and systems thinking than others who more naturally embrace reductionism.<sup>5</sup> Assumptions about the motivations for human behaviour vary, as does the awareness of social construction of knowledge.

Two other differences deserve particular attention in the context of this discussion. One is the degree to which disciplines are policy-oriented or not, and thus the contribution they can make to policy-relevant R&D. Disciplines such as economics, public policy and law are closely oriented to policy processes and issues, and have complex, refined approaches to policy. 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 in this. Policy-oriented disciplines may be expected to have more sensible things to say about policy. But if existing policy processes and instruments are deficient in fundamental ways, as many concerned with sustainability believe, then the contribution of traditional

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5. However, some differences may be determined by terminology. Systems analysts from various natural science disciplines use particular terms and concepts that appear foreign to other disciplines. But when concepts such as path-dependency, feedback loops, state variables, sensitivity to initial conditions, thresholds, etc, are translated, most political scientists or historians, for example, would find them unremarkable, everyday parts of their own understanding of the world. The issue in such cases may be communication and mutual understanding rather than radical re-learning of the world.

economics, law or public policy (for example) might be viewed with suspicion. The second is the quantitative-qualitative divide, where expressions of mutual incomprehension and questions of rigour abound. At the extremes, deeply quantitative researchers find it difficult to accept that ‘rigour-without-numbers’ (ie. qualitative analysis) is possible, while they are suspected of unnecessary mathematisation and of making assumptions that allow mathematical tractability but divorce the analysis from reality. Away from these extremes remain problems of reconciling methods, data sources, and modes of analysis. With all the above, deeper differences need to be explored before more practical issues of interdisciplinary interaction are negotiated.

Beyond these inter-disciplinary distinctions, it is crucial to recognise *intra-disciplinary variation*, and not to assume that assumptions, theory and method are uniform within a discipline. Often, the heterogeneity of one’s own discipline is well understood, but other disciplines are assumed to be homogenous. Some examples can illustrate. The sub-disciplines of resource and environmental economics generally utilise neo-classical assumptions and methods, whereas ecological economists or institutional economists may not. Community ecologists will bring questions and modes of analysis to a project quite different to, say, an ecosystem theorist. Black letter lawyers approach questions differently than law-in-context researchers or sociologists of law. And so on. The choice of collaborator from another discipline is therefore a critical decision for a researcher or research team, as it will influence or even determine the theoretical assumptions, problem-definition, methods, data requirements and finding. The specific relevance and contribution of a certain disciplinary perspective in an integrative research proposal should be closely examined and questioned.

Finally, a note on the roles of researchers at different stages of career. Integrative research has inherent risks: of failure, of difficulty in publishing, and of not fitting professionally into research institutions and incentive systems still largely defined by traditional disciplines. Those risks are more acute for younger than for older, established researchers. That said, it is the case that much of the most innovative interdisciplinary research is being undertaken by early career researchers and post-graduates. Many researchers do not have the time, resources or even mandate to develop familiarity with theory and methods of another discipline (or more than one), or to work on methodological development or substantial empirical investigation. It should be emphasised that the new ‘interdisciplines’—ecological economics or environmental history, for instance—are very small and lack influence when compared to, say, neoclassical economics or traditional historical research and writing.

### ***Methodological development, and applied problem-solving.***

These various forms of interdisciplinary combination may seek to enhance understanding, but just as commonly—and often in concert with policy agencies or stakeholder groups—the aim will be the development of analytical methods and decision- or policy-support techniques designed to integrate environment, social and economic factors. At times, R&D may involve not only development of techniques but also apply them in an actual policy or management context. The distinction between the two may be (and often should 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 aspect more complicated than suggested by the more traditionally understood continuum of basic-applied research.

There are far too many actual or potentially integrative techniques and methods to cover here, so illustrative examples will suffice.<sup>6</sup> 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 morphology. Some methodological development may stem from a questioning of the appropriateness adapting existing approaches. Examples are multi-criteria analysis (MCA) that does not rely on economic values, as an alternative to CBA, or integrated 'green accounting' as a deeper (highly contested) integrative strategy to correct perceived deficiencies in the national accounts. All such approaches have their own variations, and can be used in either informative or decisive modes. For example, MCA can seek to integrate all factors into a single recommended option, or it may be used in a more discursive and heuristic fashion to assist, but not instruct, stakeholders and the decision maker in their deliberations. Some approaches are particular to one set of users, such as 'triple bottom line' accounting, which seeks to operationalise the policy integration principle (environmental, social, economic) in the operations of (mostly larger) private firms.

There is a critical link between operational methods and techniques and deeper interdisciplinary interaction. Integrative methods can easily be utilised without shared understanding of the beliefs, 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 totally unaware of deep contests over its underlying assumptions (eg. reliance on willingness-to-pay rather than willingness-to-avoid). Any integration program or initiative should seek to make all proposals methodologically explicit and to encourage exposure of the assumptions that lie behind operational tools.

### ***Policy processes, organisational structures and institutional settings***

The third broad means of integration is in the creation of policy processes, institutional settings and organisational structures that encourage or enforce integration of environmental, social and economic factors in policy and decision making. It is widely proposed that traditional divisions of responsibilities and information across portfolios and agencies is a barrier to integration and thus to sustainability. Again, disciplinary or interdisciplinary research may inform such design, although it is likely that a smaller range of policy-oriented disciplines would be involved. Or, it may be that policy process and institutional design is deemed the realm of the bureaucracy or executive government and therefore whatever disciplinary backgrounds are to be found there.

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6. A consolidated description of existing and potential integrative methods, including discussion of their aims and limits, would be a worthwhile task.

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, forests and lands) is a partially integrative strategy tried in many jurisdictions. ICM is a leading example of new institutional reforms meant to enhance integration. Cross-sectoral policy (eg. oceans, biodiversity) addresses integration, as does legislation imposing responsibilities for such issues. Whole-of-government integrative strategies include offices of ESD and commissioners for the environment as have recently emerged in some Australian jurisdictions, or environmental or ESD sub-committees of Cabinet. Many countries have established a multi-stakeholder national council for sustainable development or equivalent to promote coordination and integration.

It should be added that there has been a noticeable paucity of comparative, empirical evaluation of the effectiveness of various integrative strategies such as those noted above, and indeed even a lack of basic identification and description of already implemented options.

A range of public agencies and processes have potential and quite different roles with respect to integration. Traditional, discipline-defined university research centres have a different role to play than applied, multi-disciplinary centres or groups. CRCs and similar organisations may be integrative R&D providers within their defined domains (generally, issue, sector or place). Government research bureaus may seek to undertake integrative R&D alone or in partnership, or to resource such work by others. Line departments and management agencies, along with community-based local and regional NRM groups, may play a crucial role in problem definition. R&D agencies have a particular role, or the potential to fulfil one, stemming from their ability to define priorities, support R&D toward such ends and, significantly, to play the role of independent broker and linkage between R&D providers and users. However, the need to maintain existing, less integrative R&D efforts while expanding efforts towards integration raises inevitable tensions.

### ***Communication-as-integration***

As proposed earlier in this paper, communication represents an integrative strategy, either in and of itself, or as a necessary co-element with other strategies. On the first possibility, as already discussed, separate disciplines, professions and policy sectors are likely to have limited understanding of theory, methods or data in other domains, and relatively straightforward communication may serve to substantially advance integration or the potential for it. Communication of available integrative approaches both across and between R&D providers and users is also likely to be necessary.

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. This suggests close coordination within an organisation between communication strategy and integration activities. The relationship between the two is likely to vary from traditional communication of R&D outputs, given the differences with who generates and who may be recipients of information and knowledge, including multiple providers and users.

## **Integration through participation**

The modern idea of sustainability places as much emphasis on participation by the wider community 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 rather than properly explored, with the following key purposes and matching 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.
- 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, such as through community-based monitoring groups, incorporation of Indigenous ecological management, etc. This may involve two-way flows of knowledge between community and formal knowledge systems, or collaborative research (participatory research).

There is a tendency to conflate participatory research and interdisciplinary research, and while they may well overlap the distinction should be maintained for clarity. For example, an economist and ecologist may collaborate to develop a new, integrative method for addressing conflicts between biodiversity conservation and production on private land. Although interdisciplinary, no one else was involved. The ecologist however also undertook separate research on remnant vegetation ecology in close and mutually rewarding partnership with local landholders: participatory but not interdisciplinary. Participation in management, or even in monitoring, 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 on par with formal disciplinary knowledge.

## **Who integrates: roles and skills**

Implicit in much of the preceding discussion of the multiple purposes and forms of integration is the clear reality that a large array of disciplines, interdisciplinary enterprises, professions and parts of the wider community have the ability or potential to contribute to integration in ESD and NRM. Who can contribute what to a specific process or project will vary endlessly according to the problem at hand, emphasising the importance of the problem definition phase and of a problem focus in integration. As an illustration, the Appendix to this paper shows one construction of the elements of an

NRM/ESD policy process, matched with disciplines that have relevance to that element. The illustration is indicative only, and does not include public agencies, professions and community or traditional knowledge systems.

A crucial factor in problem definition in the research process, and thus of who contributes to a particular R&D project or program, is that very often a single individual or limited group defines the initial problem and seeks support for or involvement in an R&D project. Without an unusually wide grasp of many disciplines, the problem definition and thus inputs to the R&D process may be constrained. That reinforces the need for greater understanding of the potential contribution of different knowledge systems as a general condition favouring integration. It also suggests a key role for organisations and individuals that are independent, disinterested in particular disciplinary or methodological advocacy, and whose interests cut across sectors and issues, as ‘brokers’ in the integration project.

## Scale and integration

In seeking to understand and manage linked environmental, social and economic systems, integration for ESD/NRM must deal with interactions across multiple spatial and temporal scales.<sup>7</sup> Some elements of this are well enough appreciated, such as disjunctions between political and ecological or hydrological boundaries, or between the temporal scales over which ecological, political and economic processes operate. Such disjunctions represent research challenges as well as practical policy and management issues. Close attention is required to this in R&D design.

However, in interdisciplinary R&D, the issue can be subtle and profound, as particular 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 and not easily communicated by those within the discipline. 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 be sensitive to these differences and to seek clarity in the problem definition and R&D design stages through justification of the chosen or implicit scale with reference to the problem at hand, and of the degree to which methods or findings can be transferred across scales.

## Interconnections and learning

Categorisations such as the preceding ones are useful and necessary tools for recognising the multiple aspects beneath a term, such as integration, that tends to be used as if it has unitary meaning. A finer resolution understanding of integration is essential to efficient and effective research and development, however there are blurred

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7. For a further discussion, see Dovers 2004.

boundaries and (potential or actual) interconnections between these different dimensions of integration that are as important as the separation of them.

For example, the driving purposes of integration are closely related, or at least can be. Integrated research to deepen understanding of linked phenomena can of course inform, for example, policy design to manage such phenomena, or at least it can if that potential is foreseen and designed into the research problem and approach. Similarly, theoretical inquiry may be a necessary precursor to methodological development, and must be explicitly so if the method under development is to be informed by different disciplinary questions. Or, the integration of community knowledge into policy and management is related to agency structure and policy process design.

The benefits of recognising interconnections include the potential efficiency of achieving multiple objectives through single efforts or investments, and a reduced likelihood of poor outcomes through incorrect problem framing. It is relatively easy but insufficient to claim or even demonstrate, for example, the relevance, in a general sense, of integrative research to integrated NRM policy or practice. It is necessary to specify precisely *how the connection can be achieved*, whether through research design or later communication strategies.

Given the differing purposes and forms of integration, numerous individuals and organisation will be engaged in a necessarily fragmented experiment over the years to come. Hence it can be expected that it will be difficult to maintain coherent directions and shared awareness of theoretical, methodological and practical developments. This suggests that coordination and communication—and most especially the learning enabled by those—will be important.

A brief further comment regarding ongoing learning is warranted. A conceptual framework for considering learning in ongoing research and assessment processes involving some degree of integration has been developed by Siebenhuner (2002), drawing on the organisational learning literature and analysis of major international environmental assessment processes. This provides some core concepts suited to the Australian NRM R&D context:

Structural factors:	Exchange of individuals Storage of knowledge Hierarchy/leadership Communication structures Reflective mechanisms
Cultural factors:	Values, norms and beliefs Informal communication networks
Personal factors:	Individual capabilities Dissatisfaction, conflicts
<i>In combination, and affected by:</i>	
Contextual factors:	Political pressure New scientific findings Media coverage Other assessments

*To produce three forms of learning:*

1. Single-loop learning: involving the adaptation of new knowledge to an already-held theory of action, with no change to this theory of action (simple error correction).
2. Double-loop learning: involving error correction but also including existing theories of action as objects of learning and thus opening the possibility of fundamental transformation of the framework of beliefs, norms and objectives.
3. Deutero learning: involving 'learning about learning', with improving the capacity to learn and adapt being an explicit goal.

Integration is a long-term and uncertain project, and so the need to develop learning capacity should be highly apparent, as should be role of communication as central to learning. Crucial to that is identification of key groups within the policy community and their differentiated interests in integration and knowledge needs. An understanding of basic elements of learning within the R&D process, shared between research providers, funders and users, would enhance learning capacities. Siebenhuner's framework offers one possible basis for considering whether the issue should be learning about integration, or learning about learning about integration, and of the different factors influencing such learning both within and external to a research provider or funding organisation.

## PRINCIPLES AND CRITERIA FOR INTEGRATION

As has been established, there is no single path to integration, because there are multiple purposes and forms of integration. Any consideration of designing an integrative project, or investing in integrative R&D, needs to be guided by principles or criteria that reflect this complexity. This section draws out a starting set of such principles. To begin, the following 'essential elements of interdisciplinarity' have been identified by Barnett et al (2003):

- *A problem focus*, whether the problems be applied, theoretical or methodological. Without a clearly defined problem, integrative R&D can only succeed through luck, and moreover the requirement for 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. Integrative endeavours should not be dictated solely by immediate agency agendas and anxieties, or delivered by tame consultancy.
- *A critical, reflexive capacity*, including recognition of normative elements of theory and practice. Given the magnitude of the task and the uncertainties inherent in it, sharp and constant evaluation of integrative initiatives is required—a critical stance is normal to some disciplines and professions than others. However, to not fall into a pure and non-constructive relativism, this needs to be balanced by an element of 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, traditional, etc). Without a singular path, no one integrative theory, method or practice should imagine that it has all the answers in any one situation, but especially as purposes and contexts change.

- A *systems orientation*, in terms of appreciating the whole rather than only selected parts (and encompassing both quantitative and qualitative constructions of systems). Essential to this perspective is appreciation of key properties of system such as feedbacks, path dependency and time lags, and that any 'system' under study will be open rather than closed, and influenced by external variables.
- A close appreciation of *multiple and dynamic spatial and temporal scales*, including a capacity to account for historical determinants of modern situations (and of the fact that current policy and management interventions will one day be historical determinants viewed with regret by future stakeholders).
- Appreciation of the *personal/group qualities* required to undertake interdisciplinary work, and the balance of risks and rewards in disciplinary boundary transgression. If integration is harder and different, it is unlikely that previous patterns of interaction, incentive or reward will be suitable, in research institutions, policy agencies, community groups, private firms, or family farms.

These form a basis for considering appropriate interdisciplinary strategies, and could be both sharpened and extended. Also, considering integration in policy and management as well as integration across formal disciplines, further principles can be proposed, as follow:

- The need to *recognise the many purposes of integration* (defined here as understanding linked phenomena, informing policy and management design, implementing policy and management actions; and participation) and of recognising potential interconnections and synergies between integrative projects driven by these four imperatives.
- Close connection between *problem definition and the varying contributions of different disciplines* and other knowledge systems (ie. local, Indigenous) can make to that problem, to produce specific mixes of skills and understanding to specific problems.
- The need to identify and factor in *intra-disciplinary variation*, recognising that there may be just as significant differences in implicit scale, problem definition, theory, method and data requirements within disciplines as across them, and that intra-disciplinary variation will often be opaque to those outside a particular discipline.
- Recognising *communication as central to the integration task*, in terms of communicating new integrative outcomes to potential users, and of creating or encouraging integration through communication of existing, singular perspectives to other audiences.

These principles are generic but operational enough. However, they may require further translation into a form suitable for implementation as criteria for R&D investments or to inform research design. They also may be seen as rendering integration more problematic, which is entirely consistent with the unarguable position that integrative research, policy and management is a significantly more difficult and complex problem set than non-integrated approaches, demanding that we do both more and better.

## CLOSING COMMENT

It is undeniable that there is an ‘integration’ imperative in natural resource management and especially in sustainable development more broadly. This applies across research, policy and management domains. But it is also clear that this nature of this imperative, and what we should do about it, are not well understood and in fact the subject of confusion. This paper has sought to offer some initial clarifications of the variety of drivers of integration, the different dimensions and kinds of integration, and the principles that can guide future efforts.

However, integration and interdisciplinarity are difficult, and we will be experimenting and learning how to integrate for some time to come. We will also be figuring out how to evaluate integrative efforts and judge their quality. That learning process will be advanced and hastened if different experiments can be connected, and these connections will need to bridge disciplines and interdisciplines, research and policy organisations, professions, management and policy sectors, and civil society and stakeholder groups. So, as well as investing in the ‘doing’ of integration, there should be sufficient effort in ‘organising’ integration.

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## Appendix: Elements of a comprehensive policy process for ESD/NRM (Dovers 1995), with contributing or potentially contributing disciplines.

The emphasis here is on the contribution of social sciences to ESD/NRM policy, and thus these are more differentiated than the natural sciences. The selection of disciplines is illustrative rather than exhaustive.

1. *Negotiation of social goals*—political science, philosophy, sociology, psychology, public policy, history.

2. *Exploring topicality and public opinion*—sociology, psychology, demography, statistics, economics, history.

3–5. *Monitoring human and natural systems, problem identification*—ecology, hydrology, geomorphology, etc, information sciences, demography, public policy, law, economics, anthropology, geography, public health, psychology.

6. *Assessing risk and uncertainty*—philosophy, information sciences, mathematics, statistics, ecology and other natural sciences, public policy, law, political science, psychology.

7. *Assessing existing policy settings*—political science, economics, public administration, public policy, law, history, planning, institutional and organisational theory, various natural sciences.

8. *Framing policy problems*—public policy and administration, law, sociology, psychology, natural sciences.

9–10. *Defining policy principles and developing policy statement*—political science, law, public policy, public administration, communications.

11. *Defining policy goals*—public policy and administration, law, relevant natural sciences, economics.

12. *Policy instrument selection*—all disciplines mentioned above, plus communications, education, design, engineering, public relations, public health.

13–14. *Policy implementation* (incl. planning and requirements)—public administration, law, institutional theory, public policy, accounting, geography, sociology, psychology, history, institutional and organisational theory.

15. *Compliance and enforcement*—law, economics, public policy and administration, psychology, education, communications.

16–19. *Policy monitoring and evaluation*—law, economics, accounting, public policy and administration, relevant natural sciences.

20. *Description and communication of policy program*—public policy and administration, communications, education.

*General elements applicable at all stages: public participation and cross-sectoral linkages*—education, communications, public policy and administration, political science, sociology, psychology, law, planning.