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Main Article:

Clarifying the Imperative of Integration Research for Sustainable Environmental Management

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Abstract

This paper discusses why integration is important in doing research for developing policy and practice of sustainable environmental management. The imperative of integration includes environmental, social, economic, and other disciplinary considerations, as well as stakeholder interests. However, what is meant by integration is not always clear. While the imperative is being increasingly enunciated, the challenges it presents are difficult and indicate a long term pursuit. This paper clarifies the different dimensions of integration, as an important preliminary step toward advancing mutual understanding and the development of approaches. The paper identifies the driving forces for integration, discusses when integration is required, categorises forms of integration, and proposes principles to inform research programs and projects.

Keywords: integration; interdisciplinary; environment; sustainability; research; policy

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1. Introduction

It is widely perceived that integrative approaches are required to address problems in environmental management so as to achieve *sustainable development*. Reference is regularly made to integration among disciplines, institutional systems, policies, organisations, and interventions. However, there is little consensus over how to do integration, even what integration means, or when and why it should be pursued. This should not surprise, as the integration imperative inherent in the idea of sustainability is relatively recent.

This paper clarifies what we mean by *integration research*, why and when is it needed, and how and by whom it might be undertaken. The aim is to enhance mutual understanding, rather than advocate or further develop particular integrative approaches. Section 2 notes the major claims for integration, viewed against the characteristics of sustainability problems, and comments on the current state-of-play regarding integrative policy and research. Section 3 delves deeper into the different purposes and kinds of integration, to allow a clearer view of the integration imperative. Section 4 concludes by proposing some guiding principles.

First, though, initial qualifications are required. This paper does not argue that integrated or interdisciplinary strategies are always needed. Integrative thinking is a response to the inadequacies of the non-integrative approaches. If some single-sector policy or single-discipline research has been poorly implemented, then arguing for an integrated approach may be an unnecessary diversion. Integration and interdisciplinarity are terms already in danger of becoming mere buzzwords in workshops and funding applications. To counter this danger and to ensure rigour, the *problem definition* phase in both policy and research is crucial. The problem definition should make it clear why integration must be preferred over the non-integrative alternatives.

Also, the choice is rarely binary, but rather about degrees of integration. Integration of environmental, social, and economic considerations is not always feasible or desirable. Depending on the problem, partial integration may be more appropriate. Additive (as opposed to integrative) *multi-disciplinary* research may be sufficient, as may be partial integration of community views in a policy process, or social scientists' input to the initial phases of a biophysical research project (or vice versa). For some policy challenges, modest involvement of another portfolio or agency may be sufficient. In other cases, deeper and more sustained patterns of integration may be required.

2. The Integration Imperative

The following extracts from key international documents state the need for integration:

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... (United Nations [UN], 1992)

109. 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. (UN, 2002)

Such global pronouncements open up several possibilities, and indicate different purposes and approaches--some of these are discussed in this paper.

The imperative of integration stems from recognition of the interdependence of human and natural systems, expressed in the research and policy agendas of sustainability. International and national policy and law state the "policy integration principle"--environmental, social, and economic considerations must be integrated in decision making processes to advance the higher-order social goal of an ecologically sustainable, socially desirable, and economically viable future (Berkhout, Leach, & Scoones, 2002; Elliott, 2004; Page & Proops, 2003; UN, 1992). The integration of environmental, social, and economic considerations is a challenge that requires the development of methods, processes, data streams, and so on to create *integrative capacity*. The intellectual challenge is extended by the emerging realisation that development of integrative capacity demands a sophisticated understanding of the interactions between highly complex, non-linear, and often closely interdependent human and natural systems. So, integration has two aspects: *integration in research*, to combine disciplinary perspectives and *integration in policy making*, cutting across previously

disparate agencies, issues, and sectors. These aspects indicate two different yet often related intents of integration: *informative*, to create knowledge that may inform policy and *decisive*, to formulate policy and management directions.

2.1. Different Integration Imperatives

The policy integration principle mentioned above, is only one element of the integration imperative. The nature of sustainability problems suggests several other elements, as described below (Dovers, 1997):

- *Integration in space*: Critical natural systems operate and must be managed over extended spatial scales (e.g., whole catchment systems, landscape-wide ecological functions, and nutrient cycles). Sustainability problems cut across political, legal, and administrative boundaries, requiring at least coordination if not integration or renegotiation of human system boundaries.
- *Integration in time*: This is necessary to address extended and variable temporal scales (e.g., climate, evolutionary processes, long-lived wastes, species population viability, etc., versus political or economic time scales). Besides, environmental issues are often cumulative over time.
- *Integration of disciplines and policy sectors*: The substantive issues of environmental management involve inter-connected problems (e.g., salinity, water quality, and vegetation; catchment management and fisheries), requiring knowledge from different specialised disciplines. Similarly, policies made in different sectors (e.g., public health, environmental protection, industry policy, etc.) have inter-connected effects on the environment.
- *Integration across social systems*: Systemic causes of environmental degradation are embedded in patterns of production, consumption, settlement, and governance. Therefore, integration across social systems is required in order to develop a *corrective* rather than *antidotal* response to unsustainable behaviour (Boyden, 1987). An example of corrective response would be refashioning legal and economic incentives that have led to an unsustainable land management practice, rather than simply banning it.
- *Integration of information*: The process of policy design and implementation needs to assimilate information about natural systems, economic drivers, legal and institutional contexts, and social and psychological factors.
- *Integration of knowledge systems*: In order to involve traditional and local communities in natural resource management and, more broadly, to establish partnerships among the private, public, and community sectors, the knowledge of government, civil society, indigenous peoples, etc.

2.2. Main Players and Their Motivations

While many agree that integration is required, one can notice many different notions and motivations concerning integration. For example, *integrated catchment management* is a familiar approach bringing together different aspects of resource management--vegetation, agricultural practices, soils, water, etc.--closely connected but traditionally managed through separate agencies and policies. The following analysis identifies the main players involved in this and the diversity of their notions and motivations.

- Natural scientists, with some understanding of one aspect of the biophysical system (e.g., landscape ecology, geomorphology, and hydrology), perceive interconnections that characterise resource management problems. Aquatic ecologists and hydrologists address riparian (river bank) and stream biodiversity as affected by flow regimes; geomorphologists and agronomists address interactions between vegetation and salinity recharge; ecologists join with economists to develop methods for ecosystem valuation; etc.
- Social scientists seek to incorporate social, legal, and economic dimensions into resource management, which they perceive as unduly dominated by natural science. Rural sociologists explore community understanding of biophysical issues and seek to integrate this with analyses of other disciplines. “Black-letter” lawyers (i.e., those dealing with undisputed legal principles) explore issues of non-compliance; “law in context” researchers examine regulatory implementation. Economists employ game theory and agent-based modelling to understand land managers’ behaviour, and promote tradable water rights as a policy instrument. Natural and social scientists also vary in terms of theoretical interests and applied interests. (Note: The humanities are not covered here for reasons of space, but are highly relevant too; see for example cases of history informing policy, reported in Dovers, 2000.)
- National government policy makers, interested in program delivery and expenditure of public 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 accredited plans.
- State/provincial and local governments, seeking to balance environmental objectives with regional development and employment issues, development of agricultural industries, and maintenance of downstream water supply and quantity, emphasise trade-offs between these imperatives through locally-based negotiation processes and enhanced coordination among agencies.
- Rural landholders, focused on farm viability and maintenance of the key elements of the natural resource base, concentrate on involvement at the district level community-based groups engaged in management and restoration activities, and

on tax incentives for resource conservation work.

- Urban residents, concerned with regional economic viability, seek ways of reconciling tensions between maintenance of agricultural production, luring light industry into towns, and protection of rural and natural areas for tourism.
- Some research funding agencies seek to invest in integrative research to produce integrated management strategies, although the proposed integrative approaches are contestable and the obstacles before integration are many.

While there are overlaps among such interpretations and motivations, there are also significant differences that need to be understood and negotiated if coordinated efforts are to be possible.

2.3. Nature of the Integration Task

The catchment context is a reasonably familiar one, yet the preceding analysis indicates that, even there, integration is difficult. Integration in environment and sustainability will be *significantly more difficult*, both intellectually and practically, than non-integrated approaches to research, policy, and management. It calls for a significant enlargement of intellectual and institutional resources.

There are many current integrative initiatives. Interdisciplinary endeavours such as environmental history and ecological economics operate at 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 have integrative agendas. The European Union's recent strategic environmental assessment directive seeks integration of environmental considerations into other policy sectors, and legislative provisions exist for such assessment in a range of jurisdictions. The United Nations Commission on Sustainable Development cuts across other areas of United Nations' work, and over 70 countries have established national councils for sustainable development to drive policy integration and stakeholder communication. Jurisdictions have established "whole of government" mechanisms such as commissioners for environment or central sustainability policy units. An increasing number of interdisciplinary research programs have emerged. None of these can be said to have succeeded--witness criticism of the poor incorporation of social sciences in the Intergovernmental Panel on Climate Change, low impact of the Commission on Sustainable Development within the larger United Nations system, marginal status of most national councils for sustainable development, and slow

implementation of strategic environmental assessment (for further discussion, see Connor & Dovers, 2004).

Sustainability, the agenda that created the integration imperative, is a higher-order social goal akin to democracy, justice, or equity. Such goals and any related methods are long term, pervasive, and contestable in nature. Perhaps, universally accepted integrative metrics capable of guiding decisions will never exist. Integrative approaches are not likely to obviate the necessity for difficult political choices, but may identify, describe, or even develop connections allowing informed trade-offs.

3. Purpose, Methods, and Processes of Integration

This section will seek to clarify the ends and means of integration, so as to facilitate development of new integrative initiatives and evaluation of past ones. The following topics will be discussed to bring about this clarity: the purpose of integration, methods and processes of integration, participation as an integrative strategy, the challenge of multiple spatial and temporal scales, and mechanisms of learning.

3.1. Why Integrate: Defining Purpose

The following purposes of integration can be gleaned from the current debates concerning natural resource management.

1. Integration of ecological, social, and economic factors, accepting that the pursuit of sustainability cannot be significantly advanced while these factors are considered separately. This has two components:
 - (a) understanding the interdependencies within and between natural and human systems, and
 - (b) informing the policy processes and institutional settings to enhance integrative capacity.
2. Implementation of integrated policy and management, through specific, operational prescriptions for policy instruments, institutional reform, or management interventions.
3. Integration of differing interests through community participation and stakeholder involvement in research, policy, and management.

3.2. How to Integrate: Methods and Processes

The following means for pursuing the above purposes will be discussed below: interdisciplinary research, methodological development, applied problem-solving, policy and institutional re-design, and communication for integration.

3.2.1. Interdisciplinary and Multidisciplinary Research and Development

Research that goes beyond disciplinary boundaries is core to understanding linked phenomena, and to informing policy and management settings. A history of increasing disciplinary specialisations, each with their *epistemological commitments* (Schoenberger, 2001), theories, methods, data requirements, etc., has contributed to specialist knowledge, but can work against integrated understanding.

Disciplinary research remains crucial, as does *additive* multidisciplinary research not questioning disciplinary theory and methods, or disciplinary inquiry which increases its grasp on a problem by incorporating knowledge from another discipline without questioning its assumptions or approach. Compared to these, interdisciplinary research with a *transformative potential* for the participating disciplines is harder.

Since sustainability problems appear to challenge the existing understanding and policy approaches (e.g., Becker & Jahn, 1999; Dovers, 1997; Dryzek, 1987), there is a *prima facie* case that disciplines and related professional fields, where such understanding and approaches have developed, may be deficient. Interdisciplinary research demands critical questioning of the available theories and methods. Such questioning has been a feature of some interdisciplinary activities, such as in ecological economics (e.g., Common, 1995). Assumptions in neoclassical economics regarding rational utility-maximising behaviour and consumer sovereignty have received critical attention by non-economists such as psychologists and philosophers. Other disciplines and their assumption sets (e.g., ecology, law, and public policy) have received less scrutiny. The need for transparency and critical evaluation entails that integration of disciplinary perspectives cannot be a matter of simple summation of the results, but must be core to problem definition and research design.

The potential or actual contribution of different disciplines depends on the problem context. In resource and environmental management some disciplines have been prominent in integrative projects, such as economics, rural sociology, hydrology and ecology; others such

as public policy, demography, and psychology less so. Any best possible combination of disciplines cannot be prescribed without reference to the specific context. Even the kind and degree of integration will depend on the context. 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 research project, so as to ensure relevance of the work to the institutional setting. Alternatively, sustained involvement of multiple disciplines may be required, generating new theory and method. Some disciplines, such as ecology, geography, and public policy, are already somewhat interdisciplinary in being theoretically and methodologically diverse.

Natural scientists might be expected to connect more easily with other natural scientists than with, say, qualitative social scientists, and vice versa. Connections across major disciplinary divides--social and natural sciences, humanities--might be expected to be more difficult, but it is precisely across those divides where sustainability-oriented "interdisciplines" have developed. Ecological economics is the most prominent example, although this field is dominated by economists and neo-classical theory, informed by a very partial contribution from ecology and lacking methodological development (Dovers, Stern, & Young, 2003). The mere naming of an interdiscipline does not equal integration. Ecology has been adapted most often, for example, political ecology, social ecology, and the longest-standing of all, human ecology (Barnett, Ellemor, & Dovers, 2003). Yet the contribution of ecology's evolving understanding of the structure and function of ecological systems is not always apparent in these fields.

There are key differences between disciplines and these must be confronted for effective interaction. One is the spatial and temporal scale implicit in theory and method. Another is whether approaches to natural systems assume linear and deterministic *versus* non-linear and stochastic processes. Some disciplines more readily comprehend whole-system approaches and *systems thinking* than others who more naturally embrace *reductionism*. Assumptions about motivations for human behaviour vary, as do views of the social construction of knowledge. Some differences may be terminological. For example, systems analysts use terms such as path-dependency, feedback loops, state variables, and thresholds, which might sound too specialised; but when the ideas behind these are translated, many political scientists or historians, for example, might find them unremarkable, everyday parts of their own understanding of the world. The issue in such cases may be mutual comprehension rather than radical re-learning.

Two other differences warrant noting here. One is the degree to which disciplines are policy-oriented, and thus the contribution they offer to policy-relevant research. Disciplines such as economics, public policy, and law are closely oriented to policy processes and issues, and have mature approaches to policy. The natural sciences and some social sciences, and humanities do not: it is not their topic. There is a paradox here. Policy-oriented disciplines may have much to say about policy, but if the existing policy approaches and the disciplines that wield them are indeed deficient, then the contribution of traditional economics, law, or public policy (for example) might be viewed with suspicion. Moreover, a broader conceptualisation of the policy process that captures what comes before and after the policy statement--problem framing and policy monitoring and evaluation through social debate and environmental monitoring, for example--emphasises the role of disciplines and other knowledge systems that are not policy-oriented, such as ecology, other natural sciences, sociology, philosophy, and community knowledge (Dovers, 2005).

The second is the quantitative-qualitative divide, where expressions of incomprehension and challenges to rigour abound. At the extremes, deeply quantitative researchers find it difficult to accept that "rigour without numbers" (i.e., qualitative analysis) is possible, while they are suspected of unnecessary mathematisation and making unrealistic assumptions for the sake of algebraic tractability. Away from these extremes remain problems of reconciling methods, data sources, and modes of analysis, and these require exploration before practical aspects of interaction are negotiated.

It is crucial to also recognise *intra-disciplinary variation*, and not assume that assumptions, theory, and method are in perfect harmony within a discipline. Often, the heterogeneity of one's own discipline is understood but not others'. For example, the sub-disciplines of resource and environmental economics generally utilise neo-classical assumptions and methods; ecological economists or institutional economists may not. Empirical ecologists bring questions and modes of analysis to a project different from, say, ecosystem theorists, and black letter lawyers approach legal questions differently from sociologists of law. The choice of a collaborator from another discipline will influence problem-definition, methods, data requirements, and findings, whether this is recognised or not.

Interdisciplinary research involves risks of failure, difficulty in publishing, and danger of not prospering in institutions defined by disciplines. This is especially so for early career researchers and post-graduates, yet such individuals are undertaking much innovative

interdisciplinary research. Many researchers do not have the time, resources, or mandate to develop familiarity with other disciplines, or to work on methodological development, or substantial empirical investigation. It should be emphasised that the new interdisciplines such as ecological economics or environmental history, are marginal and lack influence compared to, say, neoclassical economics or traditional historical research.

3.2.2. Methodological Development and Applied Problem Solving

Interdisciplinary collaborations may be driven by curiosity or by demand for decision- or policy-support methods. Researchers may not only develop techniques but apply them in partnership with agencies and stakeholder organisations. The process of application must take on responsibilities and liabilities within the policy system. The political nature of policy processes makes application more complicated than what is implied by the common distinction between basic and applied research.

Some integrative methods involve extending existing approaches, such as 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 original vegetation patterns or river morphology. Some methods stem from questioning of existing approaches, such as multi-criteria analysis not relying on economic values as an alternative to cost-benefit analysis, or integrated “green accounting” to correct perceived deficiencies in national accounts. All have variations and can be used in informative or prescriptive modes. For example, multi-criteria analysis may integrate factors to a preferred option or be used in a heuristic fashion to assist, but not instruct, policy makers and stakeholders.

Methods can be utilised without shared understanding of the epistemological and theoretical ideas that underpin those methods. For example, contingent valuation, a non-market valuation technique, may be used in an integrated assessment with participating scientists or managers being unaware of the debates over its underlying assumptions (e.g., reliance on willingness-to-pay rather than willingness-to-avoid). Any integrative initiative should seek to make all proposals methodologically explicit and encourage exposure of the assumptions that lie behind operational tools.

3.2.3. Policy Processes, Organisational Structures, and Institutional Settings

Integration also requires the creation of policy processes, institutional settings, and organisational structures that enable integration of environmental, social, and economic factors. Divisions of responsibilities and information across portfolios and agencies can be a barrier to integration and thus sustainability.

Many policy, organisational, and institutional remedies to fragmentation exist or are proposed; some examples follow (see Connor & Dovers, 2004; Gibson, Hassan, Holtz, Tansey, & Whitelaw, 2005; Lafferty, 2004; Lenschow, 2002; Swanson, Pinter, Bregha, Volkery, & Jacob, 2004). Strategic environmental assessment aims to embed environmental concerns across policy sectors. Environmental officers in non-environmental agencies (defence, water supply, etc.) serve a similar aim at operational management levels. Placing production and conservation functions within one portfolio (e.g., a merged department of conservation and agriculture) is a strategy tried in many jurisdictions. Integrated catchment management authorities are a new organisational form to enhance integration. Cross-sectoral policy (oceans, biodiversity, etc.) addresses integration, as does legislation allocating responsibilities for such issues. Whole of government strategies include offices of sustainability and commissioners for the environment, as well as environmental or sustainability sub-committees of the cabinet. Many countries have established a multi-stakeholder and multi-sector national councils for sustainable development. There has been little empirical evaluation of these integrative strategies, and even little description of the implementation experience.

3.2.4. Communication for Integration

Communication represents an integrative strategy, either in and of itself or as an ingredient of another strategy. Straightforward communication among disciplines, professions, and policy sectors can advance integration by facilitating mutual understanding. Communication is also necessary for the success of other strategies. Interdisciplinary research, methodological development, participation, and policy and institutional change, all involve new groupings of people, and flows of information and knowledge. Designing of suitable interactive contexts, and appropriate forms and channels of communication are necessary components of an integrative approach.

3.3. Integration through Participation

The contemporary idea of sustainability places as much emphasis on participation by the wider community as it does on environmental-social-economic integration. Key purposes of participation and corresponding mechanisms for participation are suggested below (discussed more fully in Dovers, 2005):

- To integrate community perspectives in policy debate and formulation, via inquiries, inclusive policy processes, deliberative research methods, representative membership in advisory committees, etc.
- To integrate community members into policy implementation, 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 knowledge, etc. This may involve two-way flows of knowledge between community and formal knowledge systems or collaborative (participatory) research.

Interdisciplinary research may not be participatory, and vice versa. A team of economists and ecologists may develop a method for addressing conflicts between biodiversity conservation and production on private land: although possibly interdisciplinary, it is not participatory because other stakeholders were not involved. An ecologist might undertake research on remnant vegetation ecology in close partnership with local landholders: participatory but not interdisciplinary.

Also, participation in management or monitoring does not equal participatory research unless the knowledge brought to the process by, for example, farmers or indigenous landowners, is treated as part of a valid *knowledge system* along with formal disciplinary knowledge. Recognition of a wider range of knowledge systems (or “epistemic communities”) is a consequence of the current debates concerning sustainability (e.g., Dobson, 2003; Munton, 2002).

3.4. Scale and Integration

To understand and manage linked environmental, social, and economic systems, integration must deal with interactions across spatial and temporal scales. Some elements of this are well appreciated, such as (a) disjunctions between political and ecological, or hydrological

boundaries and (b) disjunctions between the temporal scales over which ecological, political, and economic processes operate. Such disjunctions represent both research and management challenges.

In interdisciplinary research the issue can be more subtle, as scales are embedded in the theories and methods of disciplines. Disciplines may involve assumptions about scale that determine method and data in ways not apparent to those outside, and even taken for granted or half-forgotten by those within the discipline. For example, the spatial scale of law is defined by jurisdiction; in anthropology it is culturally determined; in hydrology by watersheds and in economics by individuals, firms, national economies, and trading systems. The temporal scale of law is determined by enactment of statute or common law precedent; for ecologists in multiple ways and differently again for historians. It is important to be sensitive to these differences during problem definition and research design by assessing the chosen or implicit scale against the problem at hand and to the degree to which methods or findings can be transferred across scales.

3.5. Interconnections and Learning

There are important interconnections between the dimensions of integration. For example, (a) theoretical inquiry may precede methodological development, especially if the latter is to be informed by multiple disciplines, and (b) integration of community knowledge into policy depends on the institutions and processes of policy development. The benefits of recognising interconnections include the potential of achieving multiple objectives and a reduced likelihood of poor problem framing. It is easy to identify the general relevance of integrative research to policy, but harder to specify precisely *how the connection can be achieved*, whether through research design or later communication.

Given differing purposes and forms of integration, multiple individuals and organisations will be engaged in fragmented experiments over many years. This suggests the importance of coordination and communication, and especially learning. A framework for understanding the process of learning in ongoing integrative research and assessment is offered by Siebenhuner (2002), drawing on the organisational learning literature and analysis of major environmental assessment processes. The framework highlights three forms of learning:

1. *Single-loop learning*: The assimilation of new information to an already-held *theory of action*, with no change to this theory of action.

2. *Double-loop learning*: Involving single-loop learning but also including existing theories of action as open to revision, thus opening the possibility of change in 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; therefore creating learning capacity should be a priority. Siebenhuner’s framework reveals some of the issues involved in achieving different types of learning.

4. Conclusion: Principles for Integration and Interdisciplinarity

There is no single path to integration, but rather multiple purposes and forms. The design of integration research needs to be guided by principles that reflect this. Two sets of principles will be presented below: principles for integration across disciplines and principles for integration in policy and management. The following principles for integration across disciplines are based on the work by Barnett, Ellemor, and Dovers (2003):

- A *problem focus*, whether the problems are applied, theoretical, or methodological, would provide an external standpoint against which integrative research can be assessed. Moreover, a problem focus would encourage early consideration of the skills and perspectives required.
- *Alertness* against the possible dominance of any singular policy objective would prevent the enterprise being swamped by the immediate agendas and anxieties of the lead agency.
- Given the magnitude of the task and the uncertainties inherent in it, constant evaluation of integrative initiatives is required, calling for a *critical and reflexive capacity*. This includes recognition of the normative elements of theory and practice. However, this needs to be balanced by ecological, economic, and political realism.
- *Openness* to different theories, disciplines, fields of inquiry, methods, cognate policy sectors, and knowledge systems would help us avoid being trapped in any particular integrative approach.
- Appreciating *intra-disciplinary variation*, i.e., significant differences with respect to implicit scale, theoretical preference, data requirements, etc., within individual disciplines would help.

- A *systems orientation* would facilitate better appreciation of the interconnections in our domains of study. This calls for a grasp of basic systems concepts such as open and closed systems, feedback, path dependency, and time lag.
- The subject calls for a close appreciation of the *spatial and temporal scales*. This includes a capacity to account for historical determinants of present situations.
- Interdisciplinary work requires *personal and group qualities* that facilitate border-crossing interactions.

An additional set of principles is proposed for facilitating integration in policy and management.

- Recognising the many *purposes of integration*, such as understanding linked phenomena, informing policy design, improving management actions, and promoting participation, would be required.
- Connecting the problem at hand to the various potential contributions of *different knowledge systems* would be helpful. It would prevent narrow problem definitions and facilitate policy integration.
- Recognising *communication* as central to the integration task would be crucial. Communicating new knowledge to potential users would be as important as communication among the multiple perspectives involved.

There is an evident integration imperative in pursuing sustainable environmental management. It is clear that integration is required across research, policy, and management; it is less clear to specify, what we should do about it. This paper has clarified different purposes and means of integration, and proposed principles to guide future efforts. Integration and interdisciplinarity are difficult, and we will be experimenting for some time to come. We will also be learning how to judge the quality of integrative efforts. That learning process will be accelerated if different experiments can be connected. Such connections will need to bridge many different fields of inquiry, research and policy organisations, professions, management and policy sectors, and stakeholder groups and civil society. It suggests not only a better understood set of terms and concepts, the subject of this paper, but also further strengthening of links between organisations and projects attempting integration research--not just *doing* integration, but also organising the human and institutional capital thus engaged.

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