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Title Page

Challenges to science and society in the sustainable management and use of water: investigating the role of social learning.

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Abstract:

Water catchments are characterised by connectedness, complexity, uncertainty, conflict, multiple stakeholders and thus, multiple perspectives. Catchments are thus unknowable in objective terms although this understanding does not currently form the dominant paradigm for environmental management and policy development. In situations of this type it is no longer possible to rely only on scientific knowledge for management and policy prescriptions. "Social learning", which is built on different paradigmatic and epistemological assumptions, offers managers and policy makers alternative and complementary possibilities. Social learning is central to non-coercion. It is gaining recognition as a potential governance, or coordination mechanism in complex natural resource situations such as the fulfilment of the European Water Framework Directive, but its underlying assumptions and successful conduct needs to be much better understood. SLIM (Social learning for the integrated management and sustainable use of water at catchment scale), a European Union, Fifth Framework project assembled a multidisciplinary group of researchers to research social learning in catchments of different type, scale, and socio-economic situation. Social tools and methods were developed from this research which also employed a novel approach to project management. In this introductory paper the rationale for the project, the project design intentions and realisations, and the case for researching social learning in contexts such as water catchments are described. Some challenges presented by a social learning approach for science (as a form of practice) and society in the sustainable management and use of water are raised.

Keywords: social learning, water catchments, interactive social science; praxis; governance mechanisms.

1. Introduction

This first paper in the special issue examines how the SLIM project[1] emerged as a major European research project investigating social learning for the integrated management and sustainable use of water at catchment scale. SLIM's original research questions and conceptual framing arose from particular experiences associated with the formulation of a new perspective on resource dilemmas. As such, the paper is a study of the history of ideas that constitute the initial starting conditions for SLIM and that seem important for contextualising the papers that contribute to this volume.

We start by examining *resource dilemmas* as a special context brought about by humans having become a major force of nature and by the increasingly contested means of access to, and use of, common pool resources as typified in the hydrological cycle. We trace how water catchments are traditionally characterised and explore the implications of considering catchments as if they were socially constructed. We then analyse the suitability of the dominant *governance or coordination mechanisms* for resolving resource dilemmas viz: regulation, information transfer and market mechanisms, and establish a rationale for alternative, complementary mechanisms that seem more suitable for dealing with resource dilemmas. The alternative we propose and set out to study was *social learning* achieved through a particular set of 'variables' that shaped the SLIM research design as well as evolving and becoming more coherent through SLIM case study research. Social learning, if adopted as a complementary governance mechanism, has implications for research management and practice as well as posing some challenges to science and society. These implications are discussed.

2. The SLIM project starting conditions

SLIM was one of a series of European Union (EU)-funded investigations concerned with the socio-economic aspects of the sustainable use of water (see http://cordis.europa.eu/fp5/src/ec-en7.htm; http://www.harmonicop.info/links.html).

[1] SLIM is an acronym derived for the 'Social Learning for the Integrated Management and sustainable use of water at catchment scale' project, a multi-country research project funded by the European Commission, i.e. Directorate General Research, as part of the 5th Framework Programme for research and technological development, 1998–2002; SLIM ran for 42 months from 2001 to 2004.

SLIM's focus was on understanding the application of social learning as (i) a conceptual framework, (ii) an operational principle, (iii) a policy instrument, and (iv) a process of systemic change. By elucidating each of these we wished to provide evidence as to whether a new, complementary approach to water governance was desirable and feasible.

It was no coincidence that SLIM began at the same time as the passage of the Water Framework Directive (WFD) through the European Parliament (Kaika 2003; EU 2003). As with the other projects funded at the time, the EU, as research commissioner, sought insight into the ways the WFD could be implemented not only through 'right laws' and 'right prices', but also through communicative and participatory approaches (see Ollivier 2004). SLIM was, however, not directly involved with the WFD, or its implementation *per se* – WFD implementation would only start in earnest in most of the SLIM countries towards the end of the research project. But we were conscious that the legislation would fundamentally change the historical basis of managing water in Europe (Kaika and Page 2003). It also seemed appropriate, based on our experiences in developing country settings (e.g., Röling and Wagemakers 1998), to assume that the shift within the WFD to managing water based on its ecological status would present challenges for catchment management that were new to most European policy-makers and water managers. Said one Dutch water manager who had spent 15 years in development work in Bhutan, Zambia and Brazil whom SLIM interviewed in 2003: 'When I took this job there was no-one who had any idea how to translate cubic meters of water into human behaviour'.

SLIM emerged in, and was implemented by, a group of researchers whose basic understanding of social change was influenced by work in agricultural research, rural development and extension education (Chambers and Jiggins 1987; Röling 1988; Russell et al. 1989; Watson 1992; 1996; Russell and Ison 1993; Ison and Russell 2000; Bawden 1994; Röling et al. 1994; Röling and Wagemakers 1998; Röling and Jiggins 1998; Gibbon and Jakobson 1999; Roggero et al. 1996; Powell 1996; Steyaert 2002; Hubert 2002; Leeuwis and Pyburn 2002). A majority had collaborated around common concerns in the LEARNING caucus of the European meetings of the International Farming Systems Association (IFSA) (LEARN Group 2000). As researchers we had become aware of, and begun to contribute to, an emerging third approach to extend and complement the main governance mechanisms of (i) hierarchy, comprising regulatory and information providing practices, including education and (ii) market (Powell 1994). This third approach has emerged in recent years in response to the frequent failure of instrumental and strategic reasoning based on the prevailing technical rationality on which water policies and practices are mainly built (Barraqué 2003; Pahl Wostl 2007). This 'social learning' (SL) approach is based on the idea that sustainable and regenerated water catchments are the emergent property of social processes and not the technical property of an ecosystem (Morris et al. 2007; Steyaert and Jiggins 2007). That is, desirable water catchment properties arise out of interaction (engaging in issue formulation and monitoring, negotiation, conflict resolution, learning, agreement, creating and maintaining public goods, concertation of action) among multiple, inter-dependent, stakeholders in the water catchment. We describe this overall set of interactions when it occurs in a complex natural resource arena as social learning.

Thus, if ecosystems are perceived as bounded by the conceptualisations and judgements of humans as are agreements to what constitutes an improvement, it became important to know if social learning could be done purposefully and well. In the next paper Blackmore (2007) traces the theoretical roots of social learning and the particular conceptualisations adopted by SLIM – we do not engage with these here.

Our starting position was that where such an interactive approach applies, centralised and objectified policy does not become irrelevant but can be encompassed within a broader understanding of how knowledge, and thus issues, are constructed and employed in policy processes. A 'social learning approach', we argued, provides a context for a dynamic local decentralised process, and, in the case of large watersheds, for concerted parallel local processes. 'Social learning' also rests on a different set of epistemological assumptions – that knowing occurs with the act, the process, of constructing an issue and seeking improvements (Blackmore 2007; Steyaert and Jiggins 2007). In contrast, the traditional policy instruments are built on an epistemological foundation of fixed forms of knowledge (i.e. reified understandings of the nature of the 'problem') as depicted in Figure 1. These two different foundations do not preclude their complementary use but such use requires awareness of the differences and of the implications for practice, whether in policy development, research or water management.

(Insert Figure 1 here)

At the time SLIM began there was growing interest in developing alternative approaches to water and catchment management. In North America Sabatier et al.

(2005) describe how in the past twenty years 'the traditional approach has come under increasing criticism [in part reflecting] the increasing complexity and conflict in water resource issues.' (p. 3). They point out that historically 'decision-making has been quite technocratic, with public involvement usually relegated to public hearings and comment periods that fine-tune agency proposals. The scope of decision making has generally consisted of specific types of pollution sources or specific areas within a watershed (such as the coastal wetlands) rather than the watershed as a whole.' Similar initiatives were occurring in a range of developing country settings (e.g., Carter 1998; Poats 2006; Chorlavi Group 2006).

The water sector was characterised by Pahl-Wostl (2002) as 'undergoing major processes of transformation at local, regional and global scales' and, like many technological resource management regimes, as 'inflexible and not built to adapt to changes in environmental, economic or social circumstances' (p.394). In institutional terms these particular historical features pose problems in an era of rapid change. Some argue that similar situations exist in research organisations; Syme (2005), reflecting on his own research organisation, points to the need for 'a cultural change in engaging others, including the general community, in assisting it with designing and answering the "right" questions'. The history of the water sector, and research institutions, or more specifically social research praxis, were important contextual factors when SLIM commenced.

We elaborate on these starting conditions for SLIM because one of the outcomes of SLIM was to add 'the history of the situation' as a key SLIM variable (see below) in what was to become the SLIM framework, or heuristic (Steyaert and Jiggins 2007). Russell and Ison (2000) explore how we are all limited by our own historicity in terms of the traditions of understanding out of which we think and act. Situations and indeed methods and techniques are also products of particular histories. Historical dependence and sensitivity to initial starting conditions are features of complexity. As outlined in section three, complexity is one of the key features of a resource dilemma; Law and Urry (2004: p. 400) also outline why complexity could be a new model for the social sciences.

For the purposes of this paper, and indeed the special issue, we emphasise that as our research 'system' (i.e. project) was non-deterministic, or non-linear, then its progress was sensitive to initial starting conditions and to the different traditions of understanding of those researchers who joined the project. For example, in order to drive the internal process of learning within the SLIM team, a mid-term review of country theory papers was organised and on two occasions process observers joined team workshops (see Steyaert and Jiggins, 2007, this volume). This helped the project to align its espoused theory with its theory in practice and hold team members accountable to processes of adaptive management through shared learning. In this process hard choices had to be made as to what recommendations to take on board (e.g. following the mid-term review we paid more attention to the dynamics of power in terms of social asymmetries, but were unable to meaningfully engage with gender as an issue despite its known significance. Ison et al. (2004) discuss the management of this process.

3. The resource dilemma as a new context

3.1 Entering the age of the environment

The SLIM proposal was motivated by Jane Lubchenco when, in her maiden speech as President of the American Society for the Advancement of Science[2], she claimed that ‘humans have become a major force of nature’ and backed this up with a long list of the ways in which humans were transforming the face of the earth (Lubchenco 1998). As an active member of the Resilience Alliance that includes ecologists and ecological economists (e.g., Ostrom 1992) her concern was to contribute to enhancing societies’ ability to retain their integrity in the face of shocks and surprises. The conceptual concerns of the Resilience Alliance, particularly ecological, economic, cultural and political principles of institutions for the environment (Hanna et al. 1996), influenced the design of the SLIM proposal.

The Resilience Alliance was a response to the widely shared realisation that the cyclical dynamics of ecosystems was incompatible with the linear growth pursued by economic policies, a fact that would invariably lead to weakened ecosystems and vulnerable societies, as Holling and his collaborators (Gunderson et al. 1995) phrased it. Holling’s lemniscates model of the cyclic nature of ecosystems, later applied to human organisations by Hurst (1995; see also Jiggins et al. 2007 and Toderi et al. 2007, this volume), was the basis for ‘adaptive management’, i.e. learning, experimentation and careful probing, as a realistic approach to capturing human opportunity. The Gunderson et al. (1995) volume explicitly mentions social learning,

[2] Later she acted as an important contributor to the Millennium Ecosystem Assessment (UN 2006).

not in Bandura's (1977) sense of imitation, but in the sense of learning by a collective to engage in more appropriate concerted action (Parsons and Clark 1995).

Earlier, Funtowicz and Ravetz (1993), referring to Kuhn's (1970) work on paradigm shifts in science, had spoken of the emergence of the need for a 'post-normal science' to deal with fundamental uncertainty with respect to highly salient issues for which puzzle solving science no longer provides satisfactory answers. This post-normal science would require 'extended peers' who included not only academic disciplinarians but also a wider public that had to live by the results, and 'extended facts', which included not just causes but also reasons. Given the basic uncertainties of the environmental crisis, answers would need to arise from widespread participation and democratisation of science.

In 1992, the translation appeared of the work of Beck (1986) on the risk society and the need for 'reflexive modernisation' i.e., a society capable of reflecting at multiple levels about its own circumstances. It is argued that a society, whose greatest risk is its own collective impact on the very thin troposphere on which all life depends (Flannery 2005), needs to manage 'second-order emergence' (Gilbert and Troitzsch 1999). The concept of second order emergence, common in artificial life studies, and defined as an emergent behaviour that adds additional functionality in a system (Steels 1990) can be distinguished from first order emergence, defined as a property not explicitly programmed in. With second-order emergence the system can use its own emergent properties to create an upward spiral of continuing evolution and emergent behaviours, something that may be necessary to ensure that humans become capable of reflecting on their collective impact, particularly the implications of the unintended consequences that arise from neo-classical, or rationalist, economic theories-in-action. These inklings of a global society that takes the ecological imperative as its most serious predicament were later, hopefully only temporarily, drowned out by neo-conservativism, which has been actively engaged in thwarting climate change research (Pierce 2006).

SLIM was thus conceived from the realisation that we had entered a new age of the environment and that 'social science' had a contribution to make, although not in its traditional form. This realisation that a new, interactive form of social science was required had grown out of deliberations of the LEARN group (Hubert et al. 2000). It is a position advocated by Law and Urry (2004) when they claim that social science methods enact nineteenth century realities and that researchers doing social science now need to recognise that they create new realities. This position is more attuned to the recognition that human fate is no longer only a question of controlling nature, but especially also one of learning how to deal with ourselves. Within our milieu, this realisation was perhaps best formulated by Bawden and Packham (1993) of Hawkesbury College (now University of Western Sydney), with whom several prospective SLIM researchers actively collaborated at the time; they advanced the claim that sustainability is the emergent property of a soft system. In making this claim they drew on the work of Peter Checkland (1981; 1999 and with Scholes 1999), the ICI manager and chemical engineer who learned the hard way that human societies cannot be managed as ‘hard systems’ in which the goals can be assumed as given. Said Checkland: ‘It is the goals that are the bone of contention’. His theoretical work on soft systems and the development of soft systems methodology, that itself relied heavily on the work of Geoffrey Vickers (Checkland and Casar 1986), has been influential in SLIM, not in the least because of the participation of members of the Open University’s Systems Department. The group of people who later came together in SLIM actively participated in the international debate. Examples are Röling and Jiggins (2001) on adaptive management, Woodhill and Röling (1998) on social learning, and Russell and Ison (1993) on contextualised science.

3.2 The attributes of resource dilemmas

The age of the environment refers to the realisation that the context of human society has changed in quite specific ways. We call this context a resource dilemma. SLIM is predicated on an effort to elucidate this dilemma quite specifically as a prelude to proposing and testing human responses for dealing with it. We have done this not for the global level, but for the level of resource bundles, such as water catchments, lake fisheries, and other common pool resources. We define these as ‘resources (i) for which joint use involves subtractability; that is: use by one user will subtract benefits from another user’s enjoyment of the resource system, and (ii) for which exclusion of individuals or groups involves high transaction costs’ (Steins 1999:3). Most natural resources have become common pool resources. A typical example is the dialogue started up by FAO (Food and Agriculture Organisation of the United Nations), WWF (World Wide Fund for Nature), IWMI (International Water Management Institute) and some other partners upon discovery that their long-term sectoral plans for water use for respectively agriculture, nature conservation and urban household and industry needs all counted on using the same limited amount of freshwater that can be expected to be available for such purposes worldwide (http://www.iwmi.cgiar.org/dialogue/; Röling and Woodhill 2001).

Resource dilemmas have specific characteristics. Subtractability causes them to be marked by *conflict and controversy*, later referred to as 'competing claims' by Giller et al. (2005), and *inter-dependence*, in the sense that achieving one's objectives is predicated upon others reaching theirs. Jiggins et al. (2007) and Collins et al. (2007) show how difficult it can be for stakeholders in a resource dilemma to accept such inter-dependence and its consequences. Resource dilemmas are further marked by the *multiple perspectives* held by the different stakeholder groups, each with their own optimisation strategies, theories and life worlds.

Resource dilemmas do not lend themselves easily to scientific analysis and solutions. In fact, they are *complex* in that a great many factors, biophysical, social, economic and political, interact in processes that are only partially path-dependent and usually unpredictable. Their outcomes depend on socially constructed realities and human reasons which make them highly *uncertain*. But that uncertainty is also inherent in the anthropogenic ecological imperatives that humans have unleashed.

3.3 The catchment as a resource dilemma

Historically water catchments have been regarded as biophysical entities governed by hydrological characteristics and defined as a 'basin or area from which rainfall flows into a river' (Fowler and Fowler 1961). In other parts of the world, 'watershed' is used synonymously with 'catchment' (e.g., Sabatier et al. 2005). With the advent of the WFD in Europe there is also a tendency to refer to 'river basins' without being clear whether these refer to hydrological features of the landscape or to a combination of hydrological feature and administrative area. Within all of these understandings, 'catchments' are seen as definable, pre-existing entities that require managing (Barraqué 2003; Pahl Wostl 2006). This understanding is then commonly institutionalised (*sensu* North 1990) as, for example, in the New South Wales (NSW) government's Catchment Management Authorities Act 2003 (State of NSW 2006).

Institutions, and the process of institutionalising, are possibly the most significant factors characterising contemporary understandings of water catchments. We use the term institution to describe an 'established law, custom, usage, practice, organization, or other element in the political or social life of a people'; 'a regulative principle or convention subservient to the needs of an organised community' (The Oxford English Dictionary). Institutions can be policies and objectives, laws, rules, regulations, organisations, policy mechanisms; norms, traditions, practices and customs. They influence how we think and what we do (North 1990; 2005; SLIM 2004a). Institutionalising is an active process the outcomes of which are the stabilization or reification of an institution. An example is the creation of a 'river basin district' as required by the WFD or the reification of particular definitions of a catchment in legislation, as described above.

Another view, which will be elaborated upon in the next section, is that water and its physical and social characteristics creates interdependencies that must be taken into account by humans who then conceptualise particular ways of understanding water – it is through this process that some societies or professional groups come to speak of 'catchments' or 'watersheds' or 'wetlands'. Each of these terms has different meanings in particular social and professional settings and each seeks to bound the dynamics of water in a particular way, i.e. different groups make different boundary judgments (Ulrich 2002) on what constitutes their 'catchment system'. This shift entails an evolution in understanding of catchments from biophysical to socially constructed entities and has implications for policy makers, water managers and researchers. In claiming that there are advantages to understanding catchments as if they were socially constructed, we are drawing on a well established intellectual tradition (Berger and Luckman 1967) and, in particular, understandings which concern the biological basis of social constructivism (e.g., Maturana and Varela 1992; Maturana and Poerkson 2004). These understandings have wider ramifications than simply understanding changes in catchments as being human, and thus socially, induced e.g., through land use practices.

3.4 The contours of societal responses to resource dilemmas

Awareness, definition and understanding of the resource dilemma slowly emerged in the last quarter of the last century. What asked for special attention was: how do we deal with it? It was obviously amenable to regulation only to a limited extent. The market seems to largely fail in resolving resource dilemmas as exemplified by market failure in the face of climate change (Stern 2006). In fact, resource dilemmas arise when the externalities of rational choices of one set of actors spoils their use by another set. At the time the SLIM proposal was conceived, ideas about possible ways of dealing with resource dilemmas had begun to emerge. They all focused on the facilitation of the process by which people with multiple interests come to engage in concerted action with respect to the sustainable management of natural resources.

The ‘tragedy of the commons’ (Hardin, 1968) was a resource dilemma with a vengeance. Rational economic behaviour was shown to inescapably cause the destruction of a common pool resource such as an open access grazing land. The aftermath of this article saw a frantic search for explanations, not in the least for common pool resources that had been sustainably managed. The research of Ostrom (1992) and her colleagues (e.g., Dietz et al. 2003) showed that institutions limiting membership of the group using the common pool resource, regulating access and off-take, as well as interaction, surveillance and sanctions, were essential for sustainable management of the resource. Facilitation of the interaction of, and negotiation among, multiple stakeholders in a resource became an important challenge. In research in Wageningen, the formulation of the notion of a ‘platform for decision making about ecosystems’, a networking site for organisations concerned with a resource dilemma, such as a board or a committee, emphasised the importance of the ‘soft side of land use’ for sustainable natural resource management (Röling, 1994); other work with pastoralists in semi-arid Australia adopted a systemic and social constructivist perspective (CARR 1993).

An important factor for the formulation of the SLIM proposal was exposure to two experiences that reflected a point of departure in natural resource management. The first was the Farmer Field School (FFS) for Integrated Pest Management in rice (e.g., Pontius et al. 2000; van de Fliert 1993). Instead of transfer of technology by extension workers talking to farmers, the FFS emphasised discovery learning by groups of farmers, group decision making on the basis of it, and facilitation of the whole process by skilled trainers who remained in the background. A visit to a Field School makes an unforgettable impression because of the enthusiasm and empowerment of the farmers participating in it.

The second major experience was exposure to Landcare in Australia. For example, during one visit to Western Australia, people involved in writing the SLIM proposal witnessed the approach of a facilitator, who had been trained at Hawkesbury College for exactly this kind of work. She was engaged with a group of farmers in a catchment seriously threatened by erosion and salination. After agreeing on the resource categories they would use (e.g., a soil typology), these farmers were asked to each make a resource map of their properties. Afterwards these maps were digitalised and a mosaic map of the entire catchment was put together from the individual maps. Of course, many mistakes had been made. Soil types changed at property boundaries, and so forth. But in the end, all farmers agreed on the map and also agreed on the vulnerable soils in the catchment. These spanned several properties. In turn this required a collective management plan. The fences of paddocks, which had so far all been entirely designed for optimal land use within the property, now were redesigned for sustainable land use across properties. The map making had helped change individual perspectives, i.e., new understandings, to a shared perspective that allowed, through new practices, concerted action.

The concrete experiences with Farmer Field Schools in Indonesia and Landcare in Australia underpinned the notion of social learning, as concerted action, as the core concept for SLIM. The empirical evidence also demonstrated that alternative approaches to the dominant 'transfer of technology' approach could work.

4 Coordination mechanisms: towards research questions and research practice

4.1 The new context demands new forms of coordination

Because water catchments have been conventionally understood as biophysical, 'hard' systems, practices, including policy prescriptions and governance mechanisms, which reflect these understandings have been enacted. These practices would not be the same, we argue, if catchments were understood as resource dilemmas, i.e. situations of complexity, uncertainty, interdependence, multiple perspectives and controversy (SLIM 2004b). In the traditional paradigm, problems are addressed through instrumental interventions, typically through engineering works or the measurement of biophysical or ecological indicators in isolation from their social context. To the extent that the sustainable management or regeneration of water catchments requires changes of behaviour of stakeholders in the catchment, use is made of strategic reasoning. Intervention typically is attempted through imposed 'hierarchical policies', a term coined by political scientists (e.g., Powell 1994), or through self regulation of the market. Both attempt to impose control on human behaviour. The former comprise regulatory measures, usually of practices as well as providing information or education (Figure 1). Consider, for example, the following quote from the EU environment commissioner of the time: ‘The 6th Environment Action Programme [of the EU] promotes environmental development using all instruments available: legislation and penalties, grants for improvements and innovations, research and information.’ (Wallström 2003).

4.2 Coordination mechanisms

Understanding resource dilemmas as anthropogenic in nature gives rise to a need to better understand the coordination and governance of human affairs. Instrumental approaches using supply-driven technological change and market liberalisation policies based on the assumption of rational choice, and of beneficial societal outcomes of market-propelled development, are increasingly questioned, not in the least within the economics discipline itself (e.g. Stern 2006). Table 1 provides a summary of the characteristics of these policy mechanisms, identified in various social science discourses, including that of a ‘third way’ of coordinating activity described by Powell (1994) as ‘networking’. In our context ‘social learning’ is a form of networking seen as an active process.

(Table 1 about here)

Table 2 characterises the major dimensions of the three coordination or governance mechanisms. We shall not go into further detail here, except to say that most societal outcomes are the result of a mix of all three mechanisms.

(Table 2 about here)

What is clear is that the third approach is not just another fad to be let loose on unsuspecting stakeholders in water catchments, but part of a global effort to learn how people can build a sustainable and liveable future. We recognise that this third coordination mechanism has not yet crystallised into simple language, or a consistent discourse, and still entails a plethora of terms such as social learning, social capital, networks, multi-stakeholder processes, soft systems, community, institutional development, and innovation systems, to describe its features. What all of these terms emphasise is that social outcomes also depend on agreement, negotiation, conflict, empathy, compassion, solidarity, reciprocity, power sharing, rules and collective wisdom. Human reasons for action are seen as important as are natural causes and rational choices. Markets provide a good example. They are not only the outcome of supply and demand but also of institutions that emerge from history including negotiation, agreement, power games, corruption, pressure by industrial countries and multinational companies, rent seeking behaviour, and so forth. From among these possibilities our preference, a product of our history and traditions of understanding, was to focus on 'social learning'.

4.3 SLIM research questions

The juxtaposition of (i) the new context created by resource dilemmas, exemplified by water catchments, the sustainability of which can be seen as an emergent property of interaction among stakeholders, and (ii) the recognition that a complementary coordination mechanism, such as social learning, would be required to resolve resource dilemmas, generated research questions which are at the core of the SLIM design. Common to all SLIM case studies and country efforts were the following questions:

1. How does the resource dilemma manifest itself in the concrete water catchment studied? Sub-questions are: What is the nature of the competing claims and inter-dependence that emerged? What are the boundaries that have been created around the resource dilemma? What stakeholders are involved?
2. What new governance mechanisms have emerged? Sub-questions focus on forms of stakeholder participation, and the nature of the interaction among them, including the creation of platforms, conflict resolution, negotiation, learning, and deciding on concerted action.
3. What process facilitation, if any, took place? Sub-questions focused on the nature of the facilitators, facilitation and learning, the approaches they used, and the nature of the monitoring and evaluation involved.
4. What were enabling or constraining institutional frameworks and policy contexts?
5. How can the insights gained be translated into policy briefs and training curricula?

Our research questions did not just apply at country level through case study research. Another set of questions operated at a different conceptual level so as to elucidate how a shared capacity at all levels of policy making in EU countries could be developed so as to create conducive contexts for local interactive processes for sustainable management and regeneration of nested watersheds in Europe, viz:

1. What evidence is there of the need for an alternative policy approach?
2. What circumstances exemplify when 'social learning' is needed and likely to be advantageous?
3. How can conceptual and practical tools to use social learning as a deliberate (purposeful) policy instrument be provided to policy makers and water managers?
4. How can we develop a way of researching social learning which is congruent with espoused theory?

An implication for SLIM in researching these questions was that the practice of research must of necessity become a form of social learning. SLIM had to be interactive. SLIM researchers had to become stakeholders in the very processes they were researching and social learning had to become an operational concept used by all stakeholders in the process. This fundamental point of departure became operationalised in the approach that was elaborated among the SLIM partners. A special methodology team was set up to develop and share this approach and to develop use of appropriate research tools and techniques within the SLIM community.

Coordination of our own research actions in this relatively complex research design was achieved by a set of empirically grounded 'research variables'.

4.4 The SLIM variables

The SLIM project proposal was designed on a simple logic, viz: (a) Designated Stakeholders *engage in* (b) Desirable Practices, *which require* (c) Learning *based on* (d) Facilitation *made possible by* (d) Institutional Support *embedded in a* (e) Conducive Policy Context. Table 3 provides a comparison of technology transfer and farmer field schools on (a) through (e). The table shows that (a) through (e) provide a simple 'coat hanger' to examine specific approaches to the coordination of human affairs based on empirical evidence; in this case technology transfer and farmer field schools. All relevant aspects of a coordination mechanism seemed to be covered by (a) through (e), and the assumption of their internal consistency allows one to ‘see’ where the application is incoherent and weak. The set of aspects (a) through (e) became the original ‘SLIM variables’.

This structure was useful in that it provided entry points for the research and suggested a search for systemic coherence in complex situations. The comparative case studies (see Figure 1 in the opening editorial) sought to follow this logic in terms of (i) case study choice and (ii) research approach, but did not follow *ex ante* blueprints. This original heuristic informed our research design and evolved based on additional theoretical and research findings e.g., the addition of ‘an ‘ecological constraints’ variable (Table 3) and a ‘history of the situation’ variable, not depicted in Table 3 (Steyaert and Jiggins 2007).

The original heuristic was also used as a focus for the outputs from the interactive workshops (work packages) which were central to SLIM’s design. State-of-the-art thematic papers were developed by cross-country authoring groups on (i) desirable practices and ecological constraints to the sustainable use of water; (ii) stakeholders and stakeholding; (iii) conducive institutions; (iv) facilitation; (v) conducive policies; and (vi) learning processes. These in turn have been transformed into a full set of Policy Briefings (PBs), with an additional PB describing capacity building needs for social learning, for use by policy makers and water managers (see http://slim.open.ac.uk).

SLIM case studies were also chosen on the basis of an appreciation of the notion of research and researcher-in-context. This means that historical factors as well as relational factors were often key considerations. For example, case studies in France and Italy grew out of extant relationships associated with the historical location of the research organisations and researchers (Steyaert et al. 2007; Todderi et al. 2007). In the UK and the Netherlands, case studies were mainly originated *de novo*. In all, 15 case studies were completed and have been written up in 12 Case Study Monographs (CSMs–see http://slim.open.ac.uk).

In this introduction to the special issue it is not our purpose to describe all of our findings but to focus on how the initial starting conditions gave rise to a research design for social learning. The remaining papers in this issue describe how that design was realised in country-specific settings (papers 3-6 of this volume) and in the project as a whole; the main outcomes for SLIM are described in Jiggins and Steyaert (2007) and in Ison et al. (2004).

5. Some challenges to society and the practice of science in natural resource management

The problems of sustainable water management apply broadly to most natural resource management situations. Campbell (1992), working in the Australian Landcare programme, the Forest Ecosystem Management Team working on the crisis in the management of the vast publicly owned forests in the USA (FEMAT 1993), and Backhaus (1991) working on planning land use in Thailand all came to the same conclusion: it is basically a socio-economic task not a scientific or technical one. It can be claimed that this realisation is part of a broader social re-contextualisation of science.

In retrospect SLIM can be seen as part of a broader set of actions within the research community with similar experiences and motivations to our own, but which are not yet 'mainstream'. This historical move presents particular challenges to the doing of science, its role in society, and the expectations we can, or might, have of citizens (e.g., Wilsden et al. 2005). One of the emergent outcomes of our research was the realisation that despite a rigorous design and many common experiences among the research team, when it came to implementation we had to pay particular attention to our different traditions of understanding and how these related to research praxis, understood as theory informed action. This realisation holds particular challenges for 'research practice' and associated epistemological awareness.

Another major factor with the potential to constrain use of a 'social learning approach', which our research highlights, is the limited human resource capacity for enacting social learning approaches. We now consider these two challenges.

5.1 Research practice

Beck (1992) highlighted how the institutionalised rationality of scientists and experts has become a source of problems itself, rather than part of the solution. We attribute this in part to lack of awareness about modes of research practice and epistemology – the basis for claims to knowledge.

In undertaking SLIM we have found that developing action-oriented 'social' research, which complements science-based research, for policy development, brings into question the relationship between research and concerted action. It is therefore important to understand the role of researchers (and the knowledge claims they make) in the transformation process towards concerted action. This realisation led us to distinguish three researcher positions R1, R2 and R3. The first, R1, concerns observing (O), for the researcher to reflect and understand (i.e. learn). The second (R2) concerns facilitating (F), through the use of tools, skills and data, the learning of others. The third (R3) involves co-constructing knowledge-in-action with stakeholders in a joint process with shared responsibility (CoR).

Recognising that scientists/researchers are no longer the only source of expertise and relevant knowledge in dealing with resource dilemmas a fourth position, R4 can be recognised. R4 is what emerges when self-organising stakeholders engage in concerted action as active citizens. Citizenship is an expression of stakeholding through action and can be a consequence of social learning. It is therefore embodied and active (in contrast to the passive, disaffected nature of current democratic procedures). These are all roles we ourselves have adopted or seen emerge. Our awareness of them has informed the design and conduct of our work packages which did not follow the traditional allocation of work packages to discrete groups. To some extent we have monitored our own learning throughout the SLIM project, and thus have additional experience and some data on our own evolution as a community of practice (see Gibbon and Jiggins, 2003; Wenger 1998). Steyaert and Jiggins (2007) return to this issue; the other papers in this issue describe and account for their own research practices.

5.2 Educational implications for capacity building

The question of education, for enacting social learning in natural resource management situations, raises the issue of education of who for what tasks? Several broad, overlapping groups can be distinguished: (i) society at large; (ii) primary stakeholders such as land managers e.g., foresters and farmers but also communities of interest as represented for example by environmental and recreational NGOs; (iii) researchers and scientists, especially science-trained staff in government agencies; and (iv) "practitioners", the growing number of people such as project officers managing water, forests or other natural resources as the "ecosystem level."

Because dialogical processes are at the core of social learning, arising through joint action, then constraints to effective dialogue need to be taken into account when identifying educational needs. Based on the SLIM experience, constraints extend across differences in worldviews between and within groups, confusion over the functions of science and technology, and deficiencies in key skills within certain groups (SLIM 2004c).

Differences in worldviews extend into ‘models of the systems’ being managed, and more fundamentally, into philosophies of relationship with the natural world (Sterling 2001). Environmental managers with a science background for example see water functioning basically in the classical hydrological cycle, but many of the public operate on the basis of simple linear models, especially in the growing urban populations with little direct contact with natural processes. This gap extends into subjects such as systems of land tenure. Pressures on ecosystems bring new, emergent land uses for water catchments, landscape, and wildlife conservation to the fore replacing mono-functional land use so that multiple land use, or multi-functionality, becomes the basic paradigm. Since emergent land uses often reflect public goods in land and other natural resources, and hence public rights in these, concepts like outright private ownership in land are challenged. Cultures with a strong sense of public or common goods in land adjust more easily to this emergent situation than those with a stronger emphasis on absolute rights in land ownership.

Within many societies divergences in basic values and relationships with regard to the natural world are often expressed as conflicts within the dialogue. Pina and Covington (1993) for example, compared the values of scientists, “restoration ecologists” and Navajo Indian traditionalists in their approach to sustainable ecosystems. They concluded that many of the values of “restoration ecologists” were closer to the Navajos’ than to their western scientist colleagues. Differences in public reaction to major flood incidents often reflect, on the one hand, a view that natural forces are entirely manageable by human society and hence flooding stems from a failure of governance, and on the other that natural forces are only partially manageable, have their own dynamics that may or may not serve societal interests, and must partially at least be lived with.

In the context of these dynamics there is a need for practitioner skills. Modern trends in rural and agricultural development have been driven forward on the basis of three skill sets: soft systems thinking, rapid appraisal, and participative approaches supported by techniques such as semi-structured interviewing. All are carried on the back of skills of facilitation based on effective process management (Wals et al. 2004). SLIM’s experience was that these skills were highly variable and could not be assumed which led to our recommendation that they should be significant strands in training in environmental management. Wildemeersch (1999) researching the reflectivity of environmental groups in the Netherlands found that most groups focus on the product or content of their activities and pay little attention to the process. Such skills are acquired through practice, with guidance from an experienced facilitator and are rarely among the outcomes of environmental management courses of institutes of higher education.

What are the implications of the above situation for the broad groups identified? The differences in models, values, philosophies of relationships to the natural world, and lack of clarity on acceptable risk define a broad societal need that few governments or agencies address. Weaknesses in environmental management education may well reflect the gulf between the social and "hard" sciences described by Newby in his presidential address to the British Sociological Society some fifteen years ago (Newby 1991). The confusion between environmental science and environmental management is more recent. The rules of evidence and of decision making in each are different and the functions of science have changed. But there is still a need for more negotiation (e.g. regarding roles) among hard-science trained staff and others, that recognises the need for process management skills in environmental management. For other practitioners, including researchers, the lack of an apprenticeship scheme for training in process management and techniques is a major constraint to more interventionist approaches such as those practised in the SLIM project.

6. Concluding comment

Jasanoff (1999), giving an account of how risk is socially constructed, the product of deeply held cultural values and beliefs, reflects our own arguments in relation to water catchments. Built on her analysis is the claim that 'environmental regulation calls for a more open-ended process, with multiple access points for dissenting views and unorthodox perspectives' (p.150). Figure 1 can be interpreted as a response to this claim that also involves widening how 'regulation' is understood i.e., as the deployment of complementary coordination mechanisms as well as epistemological awareness or humility. Historically water catchments and their sustainable management have not been treated as resource dilemmas characterised by connectedness, complexity, uncertainty, conflict, multiple stakeholders and thus, multiple perspectives. Nor have catchments been regarded as if they are socially constructed. In addition, the main coordination mechanisms have been hierarchical and market-based (Figure 1). Command and control are at the core of hierarchical mechanisms; they have been found wanting in different ways for dealing with resource dilemmas, not least being that they are expensive to administer and enforce. Market-based mechanisms are of course subject to market failure.

We do not claim to be the only ones seeking new ways of researching complex social and biophysical phenomena, nor do we claim to be the only research group motivated to research social learning. What we now have however is a history of collaboration based on concerns about:

1. How to develop concerted action to address the collective impact of humans as a major force of nature;
2. Understanding and responding to the resource dilemma as a specific challenge for dealing with anthropogenic phenomena;
3. Developing new co-ordination mechanisms that focus on voluntary concerted and distributed action based on a common process of knowing that we have called social learning (Ison 2008);
4. Developing new approaches, including capacities, for process facilitation, new forms of institutional support and new types of conducive policies;
5. Paying more attention to supporting existing social practices that have widespread legitimacy, rather than to developing expensive solutions to replace them (e.g., Collins et al. 2007).

We submit that social learning, in concert with other coordination mechanisms, has application in research and practice in natural resource management in general and more broadly in response to the current global environmental crisis, but it needs to be better understood and institutionalised. Purposeful use of social learning, with associated investment, has major implications for roles, skills and research practice that will generate important educational and training needs at a general societal as well as at a formal educational level.

7. References

Backhaus, C., 1991. Planning landuse together. ILEA Newsletter, December 1991 pp.?

Bandura, A., 1977. Social Learning Theory. Prentice Hall, Englewood Cliffs, NJ.

Barraque, B., 2003. Past and future sustainability of water policies in Europe. Natural Resources Forum 27, 200-211.

Bawden, R. J., 1994. Creating learning systems: a metaphor for institutional reform for development. In: Scoones, I., Thompson, J., (Eds.), Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice. Intermediate Technology, London.

Bawden, R.J., Packam, R., 1993. Systems praxis in the education of the agricultural systems practitioner. Systems Practice 6, 7-19.

Beck, U., 1992. Risk Society: Towards a New Modernity. Sage, New Delhi. (Translated from the German Risikogesellschaft published in 1986).

Berger, P.L., Luckman, T., 1967. The Social Construction of Reality. A treatise in the sociology of knowledge. Anchor Books, Middlesex.

Blackmore, C.P., 2007. What kinds of knowledge, knowing and learning are required for addressing resource dilemmas? – a theoretical overview. Environmental Science and Policy (this volume)

Bowles, S., Gentis, H., 2002. Social capital and community governance. Economic Journal, 112 (483), F419-F437.

Campbell, A., 1992. Landcare in Australia. In: Third Annual Report of the National Landcare Facilitator, National Soil Conservation Programme, November 1992

CARR (Community Approaches to Rangelands Research), 1993. Marketing of Middle Micron Wool. Researching with people on issues that make a difference. Monograph, University of Sydney & University of Western Sydney. 44pp.

Carter, R. C., 1998. Prospects for sustainable water management policy in Sub-Saharan Africa, with special reference to the northeast arid zone of Nigeria. In: Vajpeyi, D.K., (Ed.), Water Resource Management: A Comparative Perspective. Praeger, New York, pp. 107-127.

Chambers, R., Jiggins, J., 1987a. Agricultural research for resource-poor farmers I: Transfer-of-technology and farming systems research. Agricultural Administration and Extension 27, 35-52.

Chambers, R., Jiggins, J., 1987b. Agricultural research for resource-poor farmers II: A parsimonious paradigm. Agricultural Administration and Extension 27, 109-128.

Checkland, P.B., 1981. Systems Thinking, Systems Practice. John Wiley, Chichester.

Checkland, P.B., 1999. Soft Systems Methodology. A Thirty Year Retrospective. In Checkland, P.B., Scholes, J., 1999. Soft Systems Methodology in Action. John Wiley, Chichester.

Checkland, P.B., Casar, A. 1986. Vickers' concept of an appreciative system: a systemic account. Journal of Applied Systems Analysis 13, 3-17.

Checkland, P.B., Scholes, J., 1999.. Soft Systems Methodology in Action. John Wiley, Chichester.

Chorlavi Group, 2006. Building a Social Learning Network. 1998 – 2005. Rimisp Centro Latinoamericano para el Desarrollo Rural, Santiago, Chile.

Cochrane, W.W., 1958. The agricultural treadmill, In Cochrane, W., Farm Prices, Myths and Reality. Univ. of Minnesota Press, Minneapolis, pp. 85-107.

Collins, K.B., Blackmore, C., Morris, R.M., Seal, K., Watson, D., 2007. Rethinking policies and practices for multi-stakeholder managing of water catchments in the UK: A systemic approach. Environmental Science & Policy (this volume)

Dietz, T., Ostrom, E., Stern, P.C. 2003. The struggle to govern the commons. Science 302 (December 12), 1907–1912.

Douglas, M., 1986. How Institutions Think. University of Syracuse Press, Syracuse (NY).

EU [European Union], 2003. Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidance Document No 8, Public Participation in Relation to the Water Framework Directive, European Commission, Brussels.

Flannery, T., 2005. The Weather Makers. How man is changing the climate and what it means for life on earth. Grove Press, New York.

FEMAT (Forest Ecosystem Management Team), 1993. Forest Ecosystem Management: An Ecological, Social and Economic Assessment, Report, USDA Forest Service, (Place)?

Fowler, F.G., Fowler, H.W., 1961. The Pocket Oxford Dictionary. Clarendon Press, Oxford.

Funtowicz, S.O., Ravetz, J.R. 1993. Science for the post-normal age. Futures 25 (7), 739-755.

Gibbon, D., Jakobsson, K.M., 1999. Towards sustainable agricultural systems. In: Dragun, A.K., Tidsdell,C., (Eds.), Sustainable Agriculture and the Environment, Edward Elgar, UK, pp. 101 - 124.

Gibbon, D., Jiggins, J., 2003. SLIM’s own learning processes. SLIM Working Paper No. 7 (unpublished).

Gilbert, N., Troitzsch, K., 1999. Simulation for the Social Scientist. Open University Press, Buckingham.

Giller, K., Milgroom, J., Leeuwis, C., 2005. The role of social and technical innovation in resolving competing claims on natural resources. Unpublished Research Proposal, Wageningen University, Wageningen.

Gunderson, L.H., Holling, C.S. Light, S.S. (Eds) 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Colombia Press, New York.

Habermas, J., 1984. The Theory of Communicative Action. Vol. 1: Reason and the Rationalisation of Society. Beacon Press, Boston.

Hall, A., Janssen, W., Pehu, E., Rajalahti, R., 2006. Enhancing Agricultural Innovation: How to go beyond strengthening research systems. World Bank, Washington.

Hanna, S.S., Folke, C.,. Mäler, K.G., 1996. Rights to Nature. Ecological, Economic, Cultural, and Political Principles of Institutions for the Environment. Island Press, Washington, D.C.

Hardin, G., 1968. The tragedy of the commons. Science 162, 1243-1248.

Hurst, D.K., 1995. Crisis and Renewal. Meeting the crisis of organisational change. Harvard Business School Press, Boston (Mass.).

Hood, C., 1998. The Art of the State. Culture, Rhetoric and Public Management. Clarendon Press, Oxford.

Hubert, B., Ison, R.L., Röling, N., 2000. The 'problematique' with respect to industrialised country agricultures. In LEARN, (Eds.) Cow up a Tree. Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries. INRA (Institut National de la Recherche Agronomique) Editions, Paris. pp. 13-30.

Hubert, B., 2002. La pratique de recherche en écologie dans une réserve naturelle : les relations entre connaissance disciplinaire et connaissance pour l'action. Questions de B.Hubert à L. Marion. Natures, Sciences et Sociétés, 10 (2), 70-75.

Ison, R.L., 2008. Systems thinking and practice for action research. In: Reason, P., Bradbury, H., (Eds.). Handbook of Action Research (2nd ed.). Sage Publications, London.

Ison, R.L., Russell, D.B., (Eds.), 2000. Agricultural Extension and Rural Development: Breaking Out of Traditions. Cambridge University Press, Cambridge, UK. 239p.

Ison, R.L., Roling, N., Watson, D., 2000. SLIM (Social Learning for the Integrated Management and Sustainable Use of Water at Catchment Scale). Project Proposal, DG Research, Brussels (accessible at http://slim.open.ac.uk).

Ison, R.L., Steyaert, P., Roggero, P.P., Hubert, B., Jiggins, J., 2004. Social Learning for the Integrated Management and Sustainable Use of Water at Catchment Scale (EVK1-2000-00695SLIM). Final Report, DG Research, Brussels (accessible at http://slim.open.ac.uk).

Jasanoff, S., 1999. The songlines of risk. Environmental Values 8, 135-152.

Jiggins, J., van Slobbe, E., Röling, N., 2007. The organisation of social learning in response to perceptions of crisis in the water sector of the Netherlands. *Environmental Science and Policy* (this volume)

Kaïka, M., 2003. The Water Framework Directive: a new directive for a changing social, political and economic European framework. European Planning Studies 11 (3), 299-316.

Kaïka, M., Page, B. 2003. The EU Water Framework Directive Part 1: European policy-making and the changing topography of lobbying. European Environment 13 (6), 314 - 327.

Kelman, H., 1969. Processes of opinion change. In: Bennis, W., Benne, K., Chin, R., (Eds.), The Planning of Change (Second Edition). Holt, Rinehart and Winston, London, pp. 222-230.

Kuhn, T. S., 1970. The Structure of Scientific Revolutions, 2nd. ed., Univ. of Chicago Press, Chicago.

Law, J., Urry, J., 2004. Enacting the social. *Economy and Society* 33 (3), 390–410.

LEARN Group [Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., . Proost, J., Röling, N. Eds], 2000. Cow up a Tree. Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries. INRA, Paris.

Leeuwis, C., Pyburn, R., Eds 2002. Wheelbarrows Full of Frogs. Social learning in rural resource management. Koninklijke van Gorcum, Assen, the Netherlands.

Lubchenco, J., 1998. Entering the century of the environment: A new social contract for science. Science 279, 491-496.

Maturana, H.R., Varela, F.J., 1992. The Tree of Knowledge, the biological roots of human understanding. Shambala Publications, Boston (Mass.).

Maturana, H., Poerkson, B., 2004. From Being to Doing. The Origins of the Biology of Cognition. Carl-Auer, Heidleberg.

Morris, R.M., Roggero, P.P., van Slobbe, E., Watson, D., 2007. Ecological factors, social learning and sustainable use of resources at catchment scale. Environmental Science and Policy (accepted).

Newby, H., 1991. One world, two cultures: Sociology and the environment. Lecture to the British Sociological Council, February 1991.

North, D., 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge.

North, D., 2005. Understanding the Process of Economic Change. Princeton University Press, Princeton.

Ostrom, E. 1992. Governing the Commons. The Evolution of Institutions for Collective Action. Cambridge University Press, New York.

Ollivier, G. (2004) An analytical understanding of the Water Framework Directive questioning its potential to enable sustainable management of water, SLIM (Social Learning for Integrated Management and Sustainable Use of Water at Catchment Scale) *Case Study Monograph 9* (available at http://slim.open.ac.uk).

Pahl-Wostl, C., 2002. Towards sustainability in the water sector - The importance of human actors and processes of social learning. Aquatic Sciences 64, 394-411.

Pahl-Wostl, C., 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. Ecology and Society 11(1), 10. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art10/

Pahl-Wostl, C., 2007. The implications of complexity for integrated resources management. Environmental Modelling and Software, 22 (5), 561-569.

Parson, E.A., and Clark, W.C., 1995. Sustainable development as social learning: theoretical perspectives and practical challenges for the design of a research program. In: Gunderson, L.H., Holling, C.S., Light, S.S., (Eds.), Barriers and Bridges to the Renewal of Ecosystems and Institutions. Colombia Press, New York. pp 428-461.

Pierce, F., 2006. State of Denial. *New Scientist* Nov. 4, 2006, 18-21.

Pina V.Y., Covington W.W., 1993. Conservation biology, restoration ecology and a Navajo view of nature. In: Sustainable Ecological Systems: Implementing an

Ecological Approach to Land Management, USDA General Technical Report RM-247.

Poats, S.V., 2006. Collaborative management of natural resources in Andean watersheds in Northern Ecuador. Final Technical Report, Mar. 2003 - Sept. 2005. Corporación Grupo Randi Randi, Quito, Ecuador. 21 p.

Pontius, J. Dilts, R., Bartlett, A., 2002. From Farmer Field Schools to Community IPM. Ten Years of IPM Training in Asia. FAO, Regional Office for Asia and the Pacific, Bangkok.

Powell, N., 1996. Biodiversity conservation strategies: An assessment of the impact in regions occupied by nomadic land users; Working Paper 1996.13, Centre for Development and the Environment, University of Oslo, Norway

Powell, W., 1994. Neither market nor hierarchy: Network forms of organisation. In: Thompson, G., Frances, J., Levavcic, R., Mitchell, J. (Eds.), Markets and Hierarchies and Networks: The Co-ordination of Social Life. Sage, London, pp. 256-277.

Roggero, P.P., Porqueddu, C., Sulas, L., Caredda, S., 1996. Relationships between land use and water run-off and soil erosion in a Mediterranean environment. Proceedings of the Vth International Rangeland Congress, Logan, USA, pp. 481-482.

Röling, N., 1988. Extension Science. Information Systems in Agricultural Development. Cambridge University Press, Cambridge.

Röling, N., 1994. Platforms for decision-making about ecosystems, In: Fresco, L.O., Stroosnijder, L., Bouma, J., van Keulen, H., (Eds), The Future of the Land: Mobilising and Integrating Knowledge for Land Use Options, John Wiley and Sons Ltd, Chichester, pp. 385–393.

Röling, N., van de Fliert, E., 1994. Transforming extension for sustainable agriculture: the case of Integrated Pest Management in rice in Indonesia. Agriculture and Human Values 11 (2+3), 96-108.

Röling, N., Wagemakers, A., (Eds.), 1998. Facilitating Sustainable Agriculture. Participatory learning and adaptive management in times of environmental uncertainty. Cambridge University Press, Cambridge.

Röling, N., Jiggins, J., 1998. The ecological knowledge system. In: Röling, N., Wagemakers, A., (Eds.), Facilitating Sustainable Agriculture. Participatory learning and adaptive management in times of environmental uncertainty. Cambridge University Press, Cambridge, pp. 283-307.

Röling, N., Woodhill, J., 2001. From Paradigm to Practice: Foundations, Principles and Elements for Dialogue on Water, Food and Environment. Background Document for National and Basin Dialogue Design Workshop, December 1, 2001, Bonn. Germany.

Röling, N., 2002. Beyond the aggregation of individual preferences. Moving from multiple to distributed cognition in resource dilemmas. In: Leeuwis, C., Pyburn, R., (Eds.), Wheelbarrows Full of Frogs. Social Learning in Natural Resource Management. Koninklijke Van Gorcum, Assen, pp. 25-28.

Russell, D.B., Ison, R.L., Gamble, D.R., Williams, R.K., 1989. A Critical Review of Rural Extension Theory and Practice. Australian Wool Corporation/ University of Western Sydney (Hawkesbury). 67pp.

Russell, D.B., Ison R.L., 1993. The research-development relationship in rangelands: an opportunity for contextual science. Proc. IVth International Rangeland Congress, Montpellier, 1991. Vol. 3, pp. 1047 - 1054.

Russell, D.B., Ison, R.L., 2000. The research-development relationship in rural communities: an opportunity for contextual science. In: Ison, R.L., Russell, D.B., (Eds.), Agricultural Extension and Rural Development: Breaking out of Traditions. Cambridge University Press, Cambridge, UK, pp. 10-31.

Sabatier, P.A., Focht, W., Lubell, M., Trachtenberg, Z., Vedlitz, A., Matlock, M., 2005. Collaborative approaches to watershed management In: Sabatier, P.A., Focht, W., Lubell, M., Trachtenberg, Z., Vedlitz, A., Matlock, M., (Eds.), Swimming Upstream: Collaborative Approaches to Watershed Management. MIT Press, Boston.

SLIM, 2004a. Developing Conducive and Enabling Institutions for Concerted Action. SLIM Policy Briefing No. 3. SLIM (available at http://slim.open.ac.uk). 4p.

SLIM, 2004b. SLIM Framework: Social Learning as a Policy Approach for Sustainable Use of Water, SLIM (available at http://slim.open.ac.uk). 41p.

SLIM, 2004c. Guidelines for Capacity Building for Social Learning in Integrated Catchment Management and the Sustainable Use of Water. SLIM Policy Briefing No. 7. SLIM (available at http://slim.open.ac.uk). 4p.

State of New South Wales, 2006. Catchment Management Authorities Act 2003 (Accessed at: http://www.austlii.edu.au/au/legis/nsw/consol_act/cmaa2003316/s4.html#natural_resource_management 3 August 2006.

Steels, L., 1990. Towards a theory of emergent functionality In: From Animals to Animats, Proceedings of the First International Conference on Simulation of Adaptive Behavior. Bradford Books (MIT Press), Cambridge, MA & London, England, pp. 451-461.

Steins, N.A., 1999. All Hands on Deck. An Interactive Perspective on Complex Common-Pool Resource Management Based on Case Studies in Coastal Waters of the Isle of Wight (UK), Connemara (Ireland) and the Dutch Wadden Sea. Wageningen University, Published Doctoral Dissertation, Wageningen (NL).

Sterling, S., 2001. Sustainable Education. Re-visioning Learning and Change. Schumacher Briefing No 6. Green Books, Dartington, 94p.

Stern, N. (2006) Economics of Climate Change. HM Treasury, London.

Steyaert, P., 2002. How to deal with agricultural change for sustainable management of French Atlantic coastal wetlands? Proceedings of an Interdisciplinary Dialogue: Agricultural Production and Integrated Ecosystem Management of Soil and Water, Ballina, NSW, Australia 12-16 November 2002. OECD and NSW Agriculture.

Steyaert, P., Jiggins, J., 2007. Governance of complex environmental situations through social learning: a synthesis of SLIM's lessons for research, policy and practice, Environmental Science and Policy (this volume)

Steyaert, P., Barzman M.S., Brives H., Ollivier, G., Billaud, J.P., Hubert B., 2007. The role of knowledge and research in facilitating social learning among stakeholders in natural resources management in the French Atlantic coastal wetlands. Environmental Science and Policy (this volume).

Syme, G., 2005. Integration initiatives at CSIRO: Reflections of an insider. Journal of Research Practice 1 (2), Article M3.

Toderi, M., Powell, N., Seddaiu, G., Roggero, P.P., Gibbon, D., 2007. Combining social learning with agro-ecological research practice for more effective management of nitrate pollution. Environmental Science and Policy (this volume).

Ulrich, W., 2002. Boundary critique. In: Daellenbach, H.G., Flood, R.L., (Eds.), The Informed Student Guide to Management Science, Thomson, London,:pp. 41-42.

UN (United Nations), 2006. Millennium Ecosystem Assessment (Synthesis Report). UN Foundation, Washington.

van de Fliert, E., 1993. Integrated Pest Management Farmer Field Schools Generate Sustainable Practices: A case Study in Central Java evaluating IPM training. WU Papers 93-3, Published Doctoral Dissertation, Wageningen Agricultural University, Wageningen.

Wallström, M., (2003) Margot Wallström. Commissioner for the Environment. Key Issues (Accessed at http://europa.eu.int/comm/commissioners/wallstrom/index_en.htm 25th July, 2004).

Wals, A., Caporali, F., Pace, P., Slee, B., Sriskandarajah, N., Warren, M., 2004. Education and Training for Integrated Rural Development, Elsevier, the Netherlands.

Watson, R.D., 1992. The Use of Soft Systems Approach and Rapid Rural Appraisal for Studying Agricultural Knowledge Systems. Handbook for the International Agricultural Centre, Wageningen, the Netherlands.

Watson, R.D., 1996. Integrated Catchment Management - the human dimension. Unpublished Paper, for the Aberdeen Research Consortium, Aberdeen..

Wenger, E., 1998. Communities of Practice: Learning, Meaning and Identity. Cambridge University Press, Cambridge.

Wildemeersch, D., 1999. Paradoxes of social learning: Towards a model for project-oriented group work. In: Jensen, H.J., Olesen, H.S., (Eds.), Project Studies – A late modern university reform Roskilde University Press, Roskilde, pp. 38-57.

Wilsden, J., Wynne, B., Stilgoe, J., 2005. The Public Value of Science. Or how to ensure that science really matters. DEMOS, London. 66p.

Woodhill, J., Röling, N., 1998. The second wing of the eagle: the human dimension in learning our way to more sustainable futures. In: Röling, N., Wagemakers, A., (Eds.), Facilitating Sustainable Agriculture. Participatory learning and adaptive management in times of environmental uncertainty. Cambridge University Press, Cambridge, pp. 46-69.

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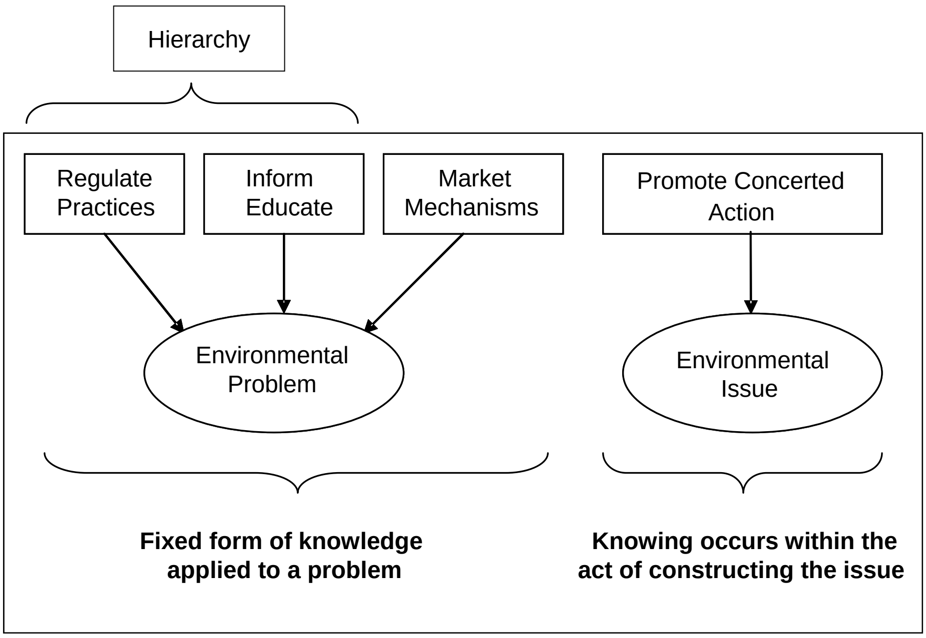
Figure

Figure 1. Policy coordination mechanisms compared (i) within the current paradigm of environmental management comprising hierarchy and the market used to address pre-determined environmental problems based on a fixed form of knowledge and (ii) social learning for concerted action based on the process of knowing.



Tables

Table 1: Three dimensions of human coordination recognised in various discourses

Discourses	***Use instruments of power***	***Assume rational choice***	***Rely on emergence from interaction***
Forms of rationality (Habermas 1984)	Instrumental	Strategic	Communicative
Basis for individual behaviour change (Kelman 1969)	Compliance	Identification	Internalisation
Preferred ways of arranging human affairs (Hood 1998)[3]	Hierarchy	Individualism	Egalitarianism
Coordination mechanisms (Powell 1994)	Hierarchy	Market	Network
Causes of ‘wealth of nations’ (Bowles and Gentis 2002)	Resources (such as power or natural resources), State power	Invisible hand of market forces	Social capital, Trust, Community
Innovation model	End of pipe outcome of technology transfer and diffusion	Induced by changes in relative factor prices; Market-propelled outcome of farmers on the treadmill (Cochrane 1958)	Emergent property of multi-stakeholder interaction (e.g. social learning; innovation systems; Hall et al. 2006)

[3] Mary Douglas (e.g. 1986), on whose work Hood (1998) is based discerns a fourth dimension, fatalism, where the sense of belonging to a group is weak, but the domination by rules is strong.

Table 2: Processes distinguishing coordination mechanisms (Adapted from Röling et al. 2002).

Coordination Mechanism

Properties	**Hierarchy**	**Market**	**Network**
Dynamics	Causation	Rational choice, Invisible hand	Exchange of meaning, Sense making, Interdependence
Mechanism behind effect	Power, Legitimation, Technology	Utility functions; Satisfying preferences	Learning processes Communication, Cooperation, Negotiated agreement, Reciprocity
Origin of welfare	Access to resources, Power, Technology	Autonomous market forces	Social capital, Trust, Community, Concerted action
Purpose	Control	Win, Gain advantage	Equity, Resolve resource dilemmas
Intervention mechanisms	Regulation, Coercion, Engineering	Laissez faire, Fiscal policy, Deregulation	Process facilitation
Criteria for success	Realisation of formal goals	Satisfaction of individual needs	Common meanings, Concerted action, Institutional change
Conditions for failure	Lack of information, No legitimation	Market failure	Inequality in power relations

Table 3: Comparison between transfer of technology and farmer field school based on a number of dimensions (following Röling and van de Fliert 1994), later adapted as SLIM variables in the SLIM research proposal (Ison et al., 2000)

Dimension	**Transfer of Technology**	**Farmer Field School**
Actors (later stakeholders)	Ultimate users of science-based component technologies	Small-scale farmers who are experts
Desirable practices	Use of productivity enhancing innovations	Sustainable management of the agro-ecosystem on the basis of regular observation and understanding. Farmer empowerment and self-organisation
Learning process involved	Adoption and diffusion of innovations	Discovery learning based on observation and experimentation by farmers, and group discussion and decision making
'Extension approach'/facilitation required	Delivery or transfer of technology through demonstrations, presentation, pamphlets	Facilitation of learning process by farmers
Institutional framework conditions	Linear and supply-driven configuration of research, delivery and utilisation	Decentralised network of expert and highly skilled facilitators and farmer trainers
Policies	Price policies, subsidies, and investments that stimulate the innovation treadmill, market liberalisation to stimulate agri-business development	Removal of subsidies on pesticides, banning of class I and broad spectrum pesticides, certification, development of Integrated Pest Management methods
Ecological imperatives (added later as a variable in the SLIM proposal)	Focus on food, externalisation of environmental costs to the environment	Focus on maintaining a broad range of ecological services, such as control of pests through natural enemies