Integration of Social Science in the UNESCO's Ecohydrology Programme

Maria Carmen Lemos
University of Michigan—USA

Jorge Recharte
The Mountain Institute—Peru

Chiung-Ting Chang
UNESCO-IHE Institute for Water Education—The Netherlands

Report submitted by the UNESCO's Ecohydrology Programme Social Science Task Force

Ann Arbor, April 18th, 2007

Executive Summary

This paper focuses on two of the most pressing issues informing the need to integrate social science into UNESCO's Ecohydrology Programme. First is the need to produce knowledge that is usable to decision-makers—from the household to public policy systems—and that integrates across the hydrological, ecological and social sciences necessary to understand the complexities surrounding water use and conservation, including drivers of unsustainable practices and their impacts on different vulnerable human-social-cultural systems. Such an approach is exemplified by Integrated Environmental Assessments (IEA). Second is a call for an analytical framework that incorporates and informs state-of-art water management options represented by Integrated Water Resources Management (IWRM).

Among the several social science resources that will be necessary to incorporate, a central one will be the family of methods for participatory planning processes. A possible future scenario for ecohydrology trained practitioners could be an appreciation and understanding of the need for active stakeholder participation as a means to obtain more relevant research questions, more meaningful results for decision-makers and innovations in water management that are grounded in society's values (Forester 1999). At this level, an interdisciplinary dialogue about modalities and methods of incorporation between natural and social scientists cooperating within the ecohydrology approach could be encouraged in order to promote integrated conceptualization.
The challenge of incorporating social science in ecohydrology demonstration sites will be to design modalities of integration that improve ecohydrology's capacity to define socially relevant problems and shape water policy implementation more effectively. The following components/steps could be considered in demonstration sites testing integration:

a. Establish dialogue mechanisms to help identify integration strategies and priorities;
b. Define a menu of integration modalities and methodologies for validation at the site;
c. Identify range of potential stakeholders and decision-makers clients and solicit their input in identifying knowledge needs;
d. Identify interactively the research questions and priority activities required from social sciences;
e. Design and deploy specific mechanisms for integration of created knowledge across the disciplines involved (both across the social sciences and across the social, hydrological, and biological sciences). These may include periodic interdisciplinary research team meetings and the creation of core structures to coordinate and foster collaboration;
f. Design and deploy specific mechanisms to foster continuous and mutually beneficial stakeholder interaction. These may include the identification of culturally sensitive indicators by different stakeholder groups and mechanisms to

assess the outcomes of water policy decisions based on research programs (through workshops, periodic outreach activities, a newsletter and interactive web capabilities);

g. Identify lessons learned concerning the efficacy of integration modalities, methods, and disciplinary research results in terms of their relevance in influencing decision makers.

A few examples of projects that can be carried out with the integration of social sciences are:

1. Valuation of environmental services, design, and introduction of market mechanisms to change consumption behavior at the basin level (see Appendix A for detailed description);
2. Institutional analysis of rules, norms and practices of water users and how they affect water consumption and conservation at different scales. This includes the application of Common Pool Resource (CPR) theory (Ostrom 1990) and examination of hybrid forms of water governance such as public-private partnerships, creation of water markets and state-community co-management (Lemos and Agrawal 2006). It also includes case study and comparative analysis of IWRM implementation across different dimensions assessing issues such as property rights regims, participation, policy networks, representation, accountability, transparency, technocratic insulation, institutional fit and interplay, sustainability, etc.;
3. Ethnographic mapping of belief systems, framings, identities and behaviors and how they shape water consumption, conservation and sustainable management (see appendix B);
4. Analysis of distributional, equity and ethical issues related to water consumption and conservation;
5. Analysis of scarcity and degradation drivers such as population growth, overconsumption, inadequate uses (through contamination with pesticides, untreated effluents, etc);
6. Political ecology and systems approaches to understand coupled human-ecological systems. These include the use of ecological and social modeling such as multi-criteria decision analysis (e.g. using STELLA) and agent based models;
7. Analysis of the human dimensions of climate change in the water sector including vulnerability mapping and adaptive capacity assessment;
8. Analysis and design of strategies for knowledge dissemination and transfer, including risk analysis, characterization of uncertainty, and diffusion and adoption studies;
9. Analysis and design of conflict resolution strategies, including in relation to transboundary and shared river basins;
10. Environmental education

1. Introduction

For the past eleven years, UNESCO's International Hydrological Programme (IHP) has been instrumental in the definition and implementation of ecohydrology as a field of inquiry and application. With eight demonstration projects and a well-established research agenda, ecohydrology activities implemented under IHP have been successful in integrating across the biological and hydrological sciences as a means to improve the sustainability of water both as an essential common good for human life and development and as provider of environmental services. However, as successful as these activities have been, gaps remain.

> Generally, ecohydrology should provide suitable approaches to gain positive feedbacks among environment, water resources, and society. However, the trend of past activities conducted under UNESCO's ecohydrology theme shows that emphasis placed on social and cultural factors has been insufficient. An important aspect that has yet to be fully addressed by ecohydrologists is the one related to people's relationship to water and the surrounding environments. There is thus a need to strengthen these aspects by bringing together concepts and methodologies from a variety of environment-related disciplines—most notably the social sciences—in order to incorporate social and cultural factors into the ecohydrology project. (Hiwasaki and Arico 2007: 62)

While there many reasons to integrate social sciences in the UNESCO's Ecohydrology Programme (Hiwasaki and Arico 2007), in this paper we focus on two of the most pressing issues informing the argument for integration. First, if we aim to produce science that seeks to inform and influence decisions at multiple scales (from the public policy process to household), we need to focus on the science-policy nexus. One principle of problem-driven science is the production of knowledge that aims at informing decision makers (at several scales) of sound alternatives to mitigate, adapt or prevent the occurrence of unwanted outcomes. The policy value of the inclusion of social science is threefold:

1. To understand how systems at different scales (from the household to policy systems) make decisions can inform both policy design (what works, what does not) and implementation.
2. To understand the institutional opportunities and constraints of policy systems in using science generated knowledge
3. To understand the constraints of knowledge producing systems to create "usable" rather than merely "useful" science.

Especially regarding fresh water systems, the complexity, gravity and urgency of fresh water related problems around the world call for analytical frameworks that contribute both to the understanding of underlining causes and consequences of water stress and scarcity (including water quality) as well as to informing policy makers. One way to accomplish this goal is to carry out integrated environmental assessments (IEA) defined as “the interdisciplinary process of identification, analysis and appraisal of all the relevant natural and human processes which affect the quality of the environment and environmental resources” (Peirce 1998: 161). In the context of IEAs, the integration of social science would be one more step in the direction of the production of “usable” knowledge—defined as knowledge “which can be incorporated into the decision-making processes of all stakeholders, and which enhances their ability to avoid, mitigate, or adapt to stressors in their environment” (Lemos and Morehouse 2005: 62). We contend that in order to accomplish its goals, ecohydrology should incorporate an array of research models ranging across the disciplines and across the knowledge-based producer-user divide. The underlining assumption is that, because many factors affect water systems, in order to understand them and produce knowledge that can inform policy making, diverse modes of interaction and disciplinary integration should be considered in the context of different water systems.

Second, the complexity, exacerbation, and increasing urgency of the water scarcity problem around the world has spearheaded a significant paradigmatic shift both on the scientific research agenda focusing on water and on the institutional mechanisms for its management. Peter Gleick (2000: 127) summarizes this paradigmatic change as including “a shift away from sole, or even primary, reliance on finding new sources of supply to address perceived new demands; a growing emphasis on incorporating ecological values into water policy; a re-emphasis on meeting basic human needs for water services; and a conscious breaking of the ties between economic growth and water use” (Gleick 2000). This paradigmatic shift away from reductive disciplinary approaches to understanding water systems in a holistically and integrated way highlights the importance of adding specific, cultural, social, economic and political dimensions to ecohydrology, particularly because a significant portion of water-related research points to human water use as the main source of tension on these ecosystems (Strang 2006). It also reinforces our argument for the incorporation of an array of research models so that usable knowledge, site-specific research, may actually illuminate decision-making.

In management terms, the new paradigm is in great part represented by the Integrated Water Resources Management (IWRM) model that has become the focus of water reform in different parts of the world (UNDP 2006). Efforts to implement water management reform are going on in places as diverse as Chile, South Africa, Mexico, and Brazil with different levels of breadth, commitment, and achievement (Wester, Merrey and deLange 2003; Bauer 2004; Brannstrom, Clarke and Newport 2004; Lemos and Oliveira 2004). These reforms, which are critically shaped by the Dublin Statement of 1992, have been heavily promoted by organizations such as the World Bank, the Organisation for Economic Cooperation and Development, and the United Nations (UNDP 2006).

IEA and IWRM are essentially connected in that knowledge produced in the context of IEAs informs the implementation of IWRM and in that IWRM incorporates many aspects of the interaction between science and society such as stakeholder participation and interdisciplinarity. In this sense, they are both part of the process of producing knowledge and applying it in the management of water resources. One way to connect and improve the fit between knowledge produced by IEA and IWRM to decisions is the creation of interaction mechanisms and monitoring systems, implemented at multiple stakeholder scales, which provide the opportunity for stakeholders and scientists to exchange ideas, establish common agendas, and learn from each other. While the Ecohydrology Programme has made great strides in integrating hydrology and ecology,[1] it needs to integrate social science to address these two foci in full.

In the next sections, we discuss these two rationales—the need for integrated assessments across science and policy and the new water paradigm, in particular, IWRM—in further detail. Section 2 focuses on integrated assessments, interdisciplinarity, stakeholder involvement and the creation of usable science and section 3 focuses on Integrated Water Resource Management. Section 4 offers a critique of the current ecohydrology approach and suggests ways in which social sciences can add and expand its policy influence and relevance. Section 5 suggests specific ways in which social science can be included in current demonstration projects.

2. Integrated Environmental Assessment and interactive science[2]

Integrated Assessments: Integrated Environmental Assessments have emerged as one of the main tools to inform optimal policies and support decision-making in the management of natural resources while accounting for both environmental effects and other priorities. They are defined as "a scientific study of some problem of practical importance, with the purpose of enabling (or at least helping) someone make a decision about what actions should be taken to achieve the best effects" (Peirce 1998: 5). IEAs imply an approach in which any particular system needs to be assessed in terms of geographical, ecological, physico-chemical, socioeconomic and other characteristics in order to be useful. Pierce (1998) suggests the following steps to implement IEAs:

I. Define a policy-relevant question:
    a. Know the audience (Who will use it? How will they use it? When do they need it?)
    b. Ask a bounded question (Can it be answered within reason? Is it conducive to analysis? Is there a factual basis?
    c. Ask a useful question (Can one act on the answer?)

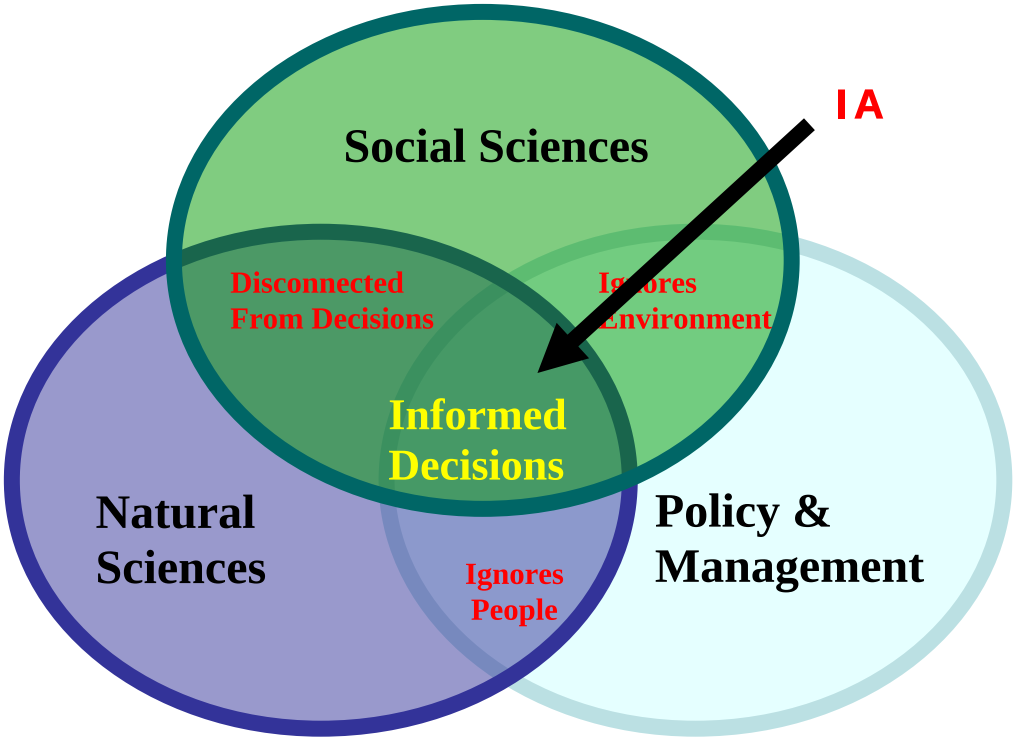
II. Document environmental, economic and social status and trends
    a. Focus on data be as rigorous as possible
    b. Drawn on accepted practices/monitoring
    c. Include social and economic data
    d. Relevant demographics and economic trends
    e. Be clear on baselines
    f. Ensure relevant time and space scales

III. Describe the causes and consequences of those trends
IV. Evaluate outcomes of a range of policy options
V. Provide technical and policy guidance for potential options

VI. Document uncertainties and science needs

Scientific assessments can be integrated both horizontally (i.e. across disciplines) and vertically (i.e. across the science-policy divide) and despite the focus on usability usually requires a combination of basic and applied science (Peirce 1998; Lemos and Morehouse 2005). Their implementation is defined across three dimensions: interdisciplinarity, interaction with stakeholders and the creation of usable science. In turn, their success is affected by three explanatory variables: (a) the level of ‘‘fit’’ between the state of knowledge production and application, (b) disciplinary and personal flexibility, and (c) availability of resources (time, funds, personnel, infrastructure, etc.). Lemos and Morehouse (2005) argue, “the higher the level of fit, interdisciplinary and personal flexibility, and availability of resources, the more likely it will be that iterativity[3] in the relation between science and decision-making will occur. In this scenario, the overall goal is to produce robust science that enhances our understanding of the many aspects of an environmental problem while producing knowledge that is useful for decision makers. Specifically in the domain of ecohydrology, it can support the evolution of learning communities in healthy social watersheds. Figure 1 (courtesy of Don Scavia), depicts the integration across disciplines and the science-policy nexus. Next, each of the dimensions of IA is examined in detail.

Figure 1: What makes IA different from conventional approaches?



Models of interactive science. Many of the influential studies on the use of knowledge-based information in policy-making have focused on the dichotomy between science produced for policy (“applied” or “decision-driven”) and science grounded on research alone (“basic” or “knowledge driven”). More recently, scholars have become increasingly interested in a third approach in which the division between science and policy is blurred and “usable” knowledge is co-produced in the context of everyday interaction between scientists, policy-makers, and the public. Bruno Latour suggests the notion of a “collective experiment,” whereby the old culture of certainty associated with pure science has been replaced by a "culture of research" in which science and society come together to ask questions and search for solutions collectively (Latour 1999).

Whereas many scholars have tackled the difficult task of reconciling knowledge production in the social sciences with policy-makers' needs (Weiss 1978; Weiss 1995), questions still remain on how to produce at the same time “usable” knowledge and high quality science. Scott et al. define interactive research as “a style of activity where researchers, funding agencies and user groups interact throughout the entire research process, including the definition of the research agenda, project selection, project execution and the application of research insights.” (Scott, et al. 1999: 4). While the authors emphasize the desirability of such an approach, they also call attention to the many constraints practitioners of interactive research face, not the least of which is the risk of compromising scientific freedom and neutrality in the definition of research agendas.

Another model of interactive research—Mode 2—is proposed by Gibbons et al. (1994), which they see as different from the more traditional knowledge-driven, primarily disciplinary, and cognitive Mode 1. Thus, Mode 2 is transdisciplinary rather than disciplinary or multidisciplinary, is carried out in non-hierarchical, heterogeneously organized forms, and involves close interactions among many actors throughout the process of knowledge creation. According to the authors, because institutionalization of Mode 2 is not occurring primarily within the university structure, and because it stresses involvement with non-academic actors and organizations, the knowledge produced is more socially accountable and the criteria for what should count as "good science" undergo careful scrutiny (Gibbons, et al. 1994: 161).

Although the calls for more socially relevant and interactive research seem to be ubiquitous, the actual engagement social and biophysical scientists in interdisciplinary efforts that involve constituent participation is a complex enterprise. For example, whereas public involvement and monitoring of the outcomes of science-based policy decisions improves local stewardship of natural resources, it also augments the challenges faced by research programs to be effective. The construction of these policy public monitoring systems was conceptualized as the "The Science of 'Muddling Through'” by Lindblom and was applied, for instance, to the management of national parks in North America (Lindblom 1959). Looking at the historical experience of managing these kinds of systems that were established to achieve specific goals set up by society, may shed some light into the challenges faced by ecohydrology to become a science grounded in society.

The mechanics of interdisciplinary knowledge creation. Whether model 1 or model 2 is followed, there are multiple challenges to deal with when setting up any cooperative research among different disciplines committed to the production of usable knowledge. In this paper, interdisciplinarity is defined as the effort of scientists from different disciplines to work together to tackle problems whose solutions cannot be achieved by any single discipline (Lemos and Morehouse 2005). Yet interdisciplinarity does not preclude scientists from different disciplines from applying their highly specialized knowledge separately to accomplish this task. Indeed, it is often a *combination* of existing disciplinary tools (sometimes modified to meet the task), instead of the *creation* of a new tool, that will offer the best approach understand and offer solutions to a problem. Here interdisciplinarity means that scientists from different disciplines must work together throughout the process to define research questions and hypotheses and work together on the dissemination of the results, including to policy systems. However, interdisciplinarity does not mean scientists will work together all the time; rather they still can (and should) work different parts of the problem separately if solving the problem so requires.

However, generating the levels of mutual understanding and trust needed to carry out interdisciplinary research effectively, especially when disciplinary and professional perspectives are widely disparate, requires open mindedness, patience, and good will, all of which require considerable time and effort. Not surprisingly, the rewards expected from interdisciplinary research must be perceived to be worth the high levels of commitment required.

Integration also requires abundant resources and funding since, in addition to funding for research, there needs to be critical investment in a coordinating structure that oversees the project and works as the "glue" that holds together the many activities within the project. Tendencies to try to fit already-existing research agendas into integrated assessment activities can also pose problems such as reduction in interdisciplinary cohesion and weakness in terms of the goodness of fit between researcher knowledge and its relevancy to stakeholder applications. Finally, involvement with stakeholders presupposes a myriad of activities not commonly part of the academic endeavor, such as long-term sustained interactions with constituents, design of specific methods for communication, and developing/sustaining bi-directional flows of information between project members and stakeholders. Such activities require considerable effort from team members and recognition that policy outcomes might be neither immediate nor complete.

Creation of usable science**:** usable knowledge is defined as that which can be incorporated into the decision-making processes of all stakeholders, and which enhances their ability to avoid, mitigate, or adapt to stressors in their environment (Lemos and Morehouse 2005: 62). In the context of IA, usable science is created by a sustainable and frequent interactive relationship with stakeholders that aims at not only understanding their needs and accelerating their rate of adoption of new knowledge but also to the fostering of stewardship among resource users towards sustainability. Figure 2 depicts the "virtuous cycle" of knowledge creation and use in the context of interaction with stakeholders. Thus in order to be useful "(knowledge) must be tailored to fit stakeholders' needs and uses…(and) be made accessible to those users." Also "the knowledge produced should directly reflect expressed constituent needs, should be understandable to users, should be available at the times and places it is needed, and should be accessible through the media available to the user community." (Lemos and Morehouse 2005: 62). The transfer and operationalization of such knowledge can be carried by a public agency, non-governmental organization, or private entity. The outcomes resulting of implementing policy-decisions based on usable knowledge should be also open to public assessment through different mechanisms, and research programs must be prepared to listen to the feedback from resource users becoming stewards and actively involved in dialogue and governance of environmental systems.

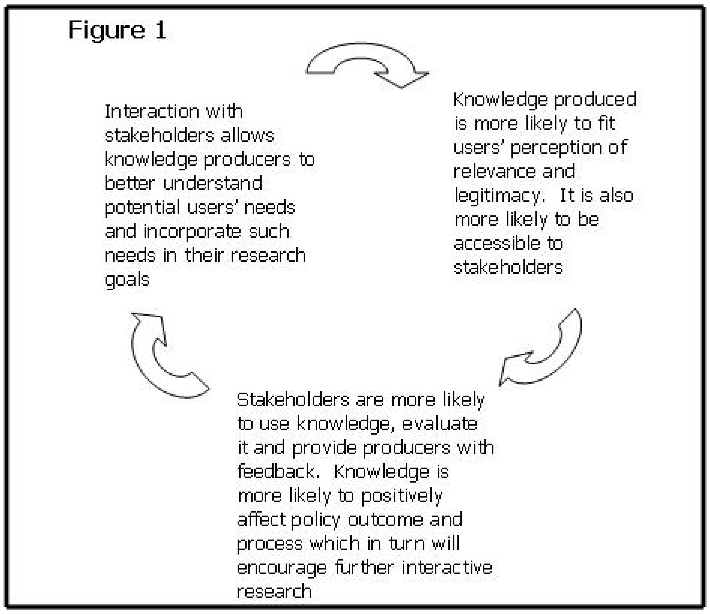


Figure 1

Interaction with stakeholders allows knowledge producers to better understand potential users' needs and incorporate such needs in their research goals

Knowledge produced is more likely to fit users' perception of relevance and legitimacy. It is also more likely to be accessible to stakeholders

Stakeholders are more likely to use knowledge, evaluate it and provide producers with feedback. Knowledge is more likely to positively affect policy outcome and process which in turn will encourage further interactive research

The means through which such knowledge is made available to users and its rate of adoption and influence is object of social science research itself. State of the art diffusion theory, for example, examines not only the opportunities and constraints for knowledge dissemination and adoption but also explores different ways in which knowledge can be tailored, packaged, evaluated and transferred to maximize its impact. Decision science also seeks to characterize uncertainties and risks associated to scientific knowledge so as to enable its use by decision makers at different scales.

3. Integrated Water Resources Management:

The implementation of IWRM has sought to integrate not only across the many disciplines needed to understand complex problems related to water use and conservation but also to design and implement institutions that are democratic, economically viable, responsive to future change, and that lead to long-term sustainability. As a management model, IWRM is inspired by three key principles of good governance:[4]

> - The *ecological principle* for integrating water management around river basins rather than independent institutional users, with land and water governance integrated for environmental reasons.
> - The *institutional principle* for basing resource management on dialogue among all stakeholders through transparent and accountable institutions governed by the principle of subsidiarity—the devolution of authority to the lowest appropriate level, from user groups at the base to local government and river basin bodies.
> - The *economic principle* for making more use of incentives and market-based principles to improve the efficiency of water as an increasingly scarce resource.(UNDP 2006: 170).

IWRM also advocates management that respects ecological limits of availability, taking into consideration not only efficiency but also equity and environmental sustainability. These goals have been accomplished by the implementation of mechanisms of water governance that have included different levels of integration and embedded ness. These sweeping water reforms usually include:

a. The reframing of water from a common public good to one with economic value. In consequence, water reforms have adopted different levels of water privatization that range to the creation of bulk water permit and charging systems (i.e. Brazil) to full-fledged water markets (i.e. Chile);
b. The creation of watershed/catchment level management councils that may include a wide range of stakeholders such as direct water users, public officials, NGOs, social movements, etc.;
c. Decentralization of water institutions to lower levels of management (the subsidiarity principle) usually, at the watershed scale;
d. Design and implementation of institutional arrangements that foster the integration across scales of governance and resource use and that take into consideration ecological limits. These include river basin plans, water zoning and creation of ecosystem protection areas;
e. Emphasis on the use of technoscience and local indigenous knowledge in the management of water reform.

Water management experiments including some or all of the characteristics described above have been implemented in several parts of the world with mixed results (Wester, et al. 2003; Bauer 2004; Lemos and Oliveira 2004). However, overall, such reforms hold great promise of building water systems capacity to respond to and to address some of the most pressing water problems including scarcity, pollution and potential negative impacts of global climate change (UNDP 2006).

4. Bringing social sciences to the Ecohydrology Programme

The evolution of the concept of ecohydrology reflects the scope of issues discussed above in connection to the production of “usable” knowledge and its application in the context of IWRM. The following revision of ecohydrology conceptual and operational models of integration of the discipline into society and the role of social sciences draws both on the preliminary conclusions of a consultative workshop convened to assess this issue (UNESCO 2005) and the analysis of this Task Force.

Conceptually defined as an integrated approach to freshwater ecosystem management and restoration, ecohydrology is organized as a problem solving approach discipline. Ecohydrology relies on the scientific understanding of ecosystem properties so that these can be used as tools for sustainable water management (Zalewski 1997). Part of the evolution of ecohydrology as a discipline is the understanding of how ecosystem properties that are connected to hydrology have been negatively affected by human action. The range of societal activities that directly or indirectly affect freshwater ecosystem properties include, for example, the direct affectation of water flow by the construction of dams, the channeling of rivers, or the construction of hydroelectric facilities; agricultural practices, including the intensification of external input uses, expanding the agricultural frontier through drainage of wetlands, or the survival practices among densely populated poor peasant populations; the expansion of potable water wells, sewage systems, linear developments such as roads and the emission of urban pollutants affecting surface or underground water flows. In summary, ecohydrology is an integrated scientific discipline oriented to the solution of hydrology and water ecosystem problems that have originated in the transformation of ecosystems as a result of anthropogenic threats. However, although ecohydrology as a scientific discipline aims to find solutions to the decline in water resources through improved ecosystem management or restoration, it has so far evolved with a “blind spot” to the understanding and management of the societal processes that are the root causes of ecosystem transformation.

Ecohydrology demonstration projects explicitly recognize the social dimension of specific water management problems affecting the site, either identifying these as causes or part of the processes that ecohydrology solutions must consider. However the specific operational presentation of the problem through hypothesis is restricted to ecosystem functioning. Thus, we may characterize ecohydrology as a multi disciplinary “supply side” approach to solving water management problems. As indicated by the consultative workshop, so far “fundamental aspects of social, cultural, political interactions affecting water use and conservation have been virtually absent from the ecohydrology approach” (UNESCO 2005). Ecohydrology has yet to validate multi or transdisciplinary research models that demonstrate ways to integrate the social sciences. Validation of these models will have to be tested by the capacity of ecohydrology to produce “usable” knowledge that responds to stakeholders and decision makers at multiple levels. Decision makers requiring practical knowledge of ecohydrology solutions are policy makers and water users. There is a need to link the study of ecohydrology solutions to human livelihoods and the sustainable use and conservation of biodiversity (UNESCO 2005).

The incorporation of social sciences into the ecohydrology approach should be assessed by its yield of effective water management decision support tools. This will clearly require from ecohydrology scientists the will to engage local society in planning processes for freshwater ecosystem management, and therefore engage specialized social science knowledge related to the nature of these kinds of processes.

In order to make ecohydrology a more effective problem-driven or applied scientific discipline, it is necessary to test flexible modalities and methods of social science integration and designing demonstration projects to test these. Demonstration projects should demonstrate the priorities for integration and how to incorporate the social sciences in ways that are effective and meaningful to both research communities and to stakeholders.

Among the several social science resources that will be necessary to incorporate, a central one will be the family of methods for participatory planning processes. A possible future scenario for ecohydrology trained practitioners could be an appreciation and understanding of the need for active stakeholder participation as a means to obtain more relevant research questions, more meaningful results for decision-makers and innovations in water management that are grounded in society's values (Forester 1999). At this level, an interdisciplinary dialogue about modalities and methods of incorporation between natural and social scientists cooperating within the ecohydrology approach could be encouraged in order to promote integrated conceptualization.

Involving the social sciences will also include the understanding of power relations affecting directly or indirectly ecosystem processes that connect to water as well as the more explicit use, access, and control of water at a range of different scales, from state institutions to households or other intermediate water related institutions. Mapping site-specific governance systems, legal systems, and decision-making or policy networks will be a fundamental role of social science in ecohydrology. Understanding the history of dynamic change in these structures of power relations and environmental governance institutions will also improve our understanding of extant institutions governing water management decisions.

The role of integrating the social sciences will be not only to identify or describe problems in these sets of sub disciplines, but to interpret these problems in terms of their implications for ecosystem management. Therefore, the building of a robust social science component in ecohydrology aims to create conditions for a meaningful dialogue between natural and social scientists regarding the definition of ecohydrology problems, hypothesis and potential solutions to freshwater ecosystem management and restoration that include managing social causes of system stressors.

Social science integration in demonstration projects. All demonstration sites have identified socio-economic issues that are perceived as problems for society such as side effects of freshwater ecosystem degradation. For instance, at the Guadiana River site in Portugal, the occurrence of algal blooms and other expressions of degradation of the freshwater ecosystems results in impacts on recreation activities and aquaculture and fisheries. Flood impacts and nutrient flows in the Danube River wetland system affect water wells and require flood protection of urban areas. The complex array of socio-economic issues in the case of a demonstration site in the river floodplains of the Amazonas sustainable management of this freshwater ecosystem is linked to the need to develop economic alternatives to forest exploitation, general socio-economic development and improved management of timber plantations. Clearly in all demonstration sites ecohydrology scientists have proposed links with social issues that are meaningful to their common sense but without engaging social scientists or society in the process.

The challenge of incorporating social science in demonstration sites will be to design modalities of integration that at the end of the process improve ecohydrology capacity to define socially relevant problems, and therefore more effective water policy implementation. The following components/steps could be considered in demonstration sites testing integration:

h. Establish dialogue mechanisms to help identify integration strategies and priorities;
i. Define a menu of integration modalities and methodologies for validation at the site;
j. Identify range of potential stakeholders and decision-makers clients and solicit their input in identifying knowledge needs;
k. Identify by consensus the research questions and priority activities required from social sciences;
l. Design and deploy specific mechanisms for integration of created knowledge across the disciplines involved (both across the social sciences and across the social, hydrological, and biological sciences). These may include periodic interdisciplinary research team meetings and the creation of core structures to coordinate and foster collaboration;
m. Design and deploy specific mechanisms to foster continuous and mutually beneficial stakeholder interaction. These may include the identification of culturally sensitive indicators by different stakeholder groups and mechanisms to assess the outcomes of water policy decisions based on research programs (through workshops, periodic outreach activities, a newsletter and interactive web capabilities);
n. Identify lessons learned concerning the efficacy of integration modalities, methods, and disciplinary research results in terms of their relevance to actually influencing decision makers.

A few examples of projects that can be carried out with the integration of social sciences are:[5]

11. Valuation of environmental services, design, and introduction of market mechanisms to change consumption behavior at the basin level (see Appendix A for detailed description);
12. Institutional analysis of rules, norms and practices of water users and how they affect water consumption and conservation at different scales. This includes the application of Common Pool Resource (CPR) theory (Ostrom 1990) and examination of hybrid forms of water governance such as public-private partnerships, creation of water markets and state-community co-management (Lemos and Agrawal 2006). It also includes case study and comparative analysis of IWRM implementation across different dimensions assessing issues such as property rights regimes, participation, policy networks, representation, accountability, transparency, technocratic insulation, institutional fit and interplay, sustainability, etc.;
13. Ethnographic mapping of belief systems, framings, identities and behaviors and how they shape water consumption, conservation and sustainable management (see appendix B);
14. Analysis of distributional, equity and ethical issues related to water consumption and conservation;
15. Analysis of scarcity and degradation drivers such as population growth, overconsumption, inadequate uses (through contamination with pesticides, untreated effluents, etc);
16. Political ecology and systems approaches to understand coupled human-ecological systems. These include the use of ecological and social modeling such as multi-criteria decision analysis (e.g. using STELLA) and agent based models;
17. Analysis of the human dimensions of climate change in the water sector including vulnerability mapping and adaptive capacity assessment;
18. Analysis and design of strategies for knowledge dissemination and transfer, including risk analysis, characterization of uncertainty, and diffusion and adoption studies;
19. Analysis and design of conflict resolution strategies, including regarding transboundary and shared river basins;
20. Environmental education

5. The potential for integrating social science into (in selected) demonstration site cases.

As mentioned above, an array of social science-based research and methodologies could be deployed in the current demonstration projects. A first component of the process could be to develop dialogue tools between natural and social scientists in each project to discuss opportunities and reach consensus. For instance, deliberation may involve, from the perspective of the social sciences the need to avoid a secondary “service role” of simply identifying stakeholder needs. Building these interactions and validating through field experiences and lessons learned on best practices of multidisciplinary research will in the end institutionalize integration and create meaningful interactions that in turn can be instrumental to integrate ecohydrology into society.

Second, in order to identify the most salient and relevant issues from a societal point of view in each basin, it is suggested that a first order of consultation with stakeholders be carried out in each site to identify priorities. Ideally, this process should be as inclusive as possible and make a concerted effort to engage especially those stakeholders who are unlikely to “self-select” that is, those without the financial or power resources to have access to information, come to meetings, or take the initiative to engage knowledge producers. In addition, mechanisms for stakeholder interaction should be implemented on a regular basis to encourage mutual learning, foster stewardship towards the project and increase knowledge transfer from project to decision-making at diverse scales.

In Appendix A and B in-depth descriptions of how two disciplines—Anthropology and Environmental Economics—could add to the Ecohydrology Programme are presented. Below, we suggest a few ways in which these and other social science approaches can be incorporated into demonstration sites research.

Specific social science activities suggested for each site

Demonstration site cases are reviewed and suggestions are made where and how social science might be helpful. These ideas are in no way exhaustive, and provide only preliminary suggestions of different ways in which social science can be incorporated in the current demonstration projects. It goes without saying that we argue for stakeholder involvement in all demonstration sites.

<u>Sustainable management of Andean-Patagonian Watershed: Improving land use policy at Lacar Lake Watershed based on an ecohydrological approach</u>

The major anthropogenic problem facing the watershed is urban expansion as a result of an increasing demand for land, resources, and waste treatment. Social science can help the understanding of these underlying conditions and produce knowledge to inform water zoning and planning in the context of sustainable IWRM. In addition, institutional research focusing on transboundary water management could inform management options. For example, what would be effective mechanisms to implement sustainable transboundary governance institutions? What tools of conflict resolution could be useful to address potential instabilities? Implementation of such management strategies must include an analysis of socioeconomic and political factors as well as a careful analysis of the basin formal and informal institutional environment at different scales of governance and use, including national and international regulations, shared practices in the basin and local norms of water use and conservation. Concerning the latter, it is critical for the project to investigate the indigenous population in the basin and how their belief systems and interaction of non-indigenous population may shape management options. The research team has already carried out selected environmental assessment activities and integrated management research in the basin, and has developed the capacity to design decision support tools (DSTs) for management decisions. However, what the demonstration project seem to lack is a well-crafted plan on how to make such tools "usable" to local decision-making. In this sense, the site could be a good case where building a close relationship with stakeholders (including indigenous groups) could be critical for the implementation of more sustainable governance mechanisms. Here state of the art research on communication and development of interactive mechanisms across the science and policy divide could be useful to narrow the gap between knowledge producers and users (e.g. organization of workshops and training sections for water and ecosystem managers, design of an interactive web tool, etc). Also understanding the institutional constraints for the adoption of innovation (e.g. how managers make their decisions, where do they look for information, what about their organizations support or constraint their use of new knowledge) could inform the project team on how "to package" or tailor their DST to different potential users.

Sustainable timber production and management of central Amazonian white-water floodplains, Mamirauá Sustainable Development Reserve, Brazil

On the one hand, promoting sustainable timber production can benefit both the environment and the local inhabitants in terms of income. On the other hand, reducing impacts of timber exploitation and creating alternative sources of income must be considered if the project is to succeed. Introducing an environmental subsidy system (or payment for environmental services) might provide a solution to both objectives. By "paying" local dwellers, the system would create an incentive structure for forest conservation, compliance with regulation and enforcement. In this case, stakeholders should be involved from planning stages so as to create a virtuous cycle of interaction and stewardship. In addition, an in-depth institutional analysis focusing on what formal and informal institutions (or lack thereof) provide incentives to non-sustainable forest use (i.e. property rights, regulation, historical patterns of forest use, etc) could be carried out. This kind of knowledge can provide the basis for the creation of sustainable practices such as Community Based Forestry (both for timber or carbon offsetting, for example). This research could be carried out through different frameworks including political ecology and complex systems (using coupled human-ecosystem modeling).

Study of inter-basin transfer of water resources and water deficit for large mammals migrating to Serengeti, Kenya and Tanzania

This demosite project focuses on a recently implemented transboundary governance system between Kenya and Tanzania. The project has many aspects where social sciences could be deployed both to understand underlining stressors and to contribute to the design of possible solutions. For example, the allocation of water during dry season can be an issue involving various conflicting interests. A study focusing on mapping the diverse institutional arrangements (i.e. water legislation, water/environmental agencies and overlapping jurisdictions, etc.) influencing water management in both countries could contribute to a better understanding of the constraints and opportunities to carry out transboundary management and anticipating bottlenecks to sustainable use. In addition, social science can be used to understand several issues informing management such as the role of indigenous groups (both as users of water and as vulnerable groups to water scarcity and pollution); understanding the differential vulnerabilities of human and water systems to climate variability and change; understanding the political ecology of the interaction between forestry and water systems; using complex system approaches to understand the interactions between different water users (including animal populations), the stressors under which they are under, and the different scales of organizational complexity (including protected areas) across the two countries. The team seems to have an initial plan to involve different stakeholders (by organizing workshops), it would be important to include social scientists in these activities from the get go, to integrate them in the project's research agenda and to provide initial data from where interdisciplinary projects can be developed.

Re-creation of artificial Cyperus papyrus wetlands surrounding the lake and at the inflowing rivers delta; basin-wide phyto-technological methods for restoration of the basin hydrology and hydrochemistry, Lake Naivasha, Malewa, Kenya

This project site has been active in implementing a stakeholder-driven approach. The most critical stressor for sustainable water use and ecosystem sustainability in this project seems to be overconsumption mostly as a function of population and agricultural pressure. One way social science could be integrated in this project would be by carrying out an in-depth study of the underling drivers of unsustainable consumption (including institutional and ethnographic research) to inform both the educational campaign the project wants to carry out but also to offer alternative options in terms of best practices that can alleviate some of this pressure. The region seems also to be a good place where vulnerability mapping could be applied to inform management options. It would also be important to continue to involve stakeholders in the restoration plans so as to promote buy-in and stewardship of ecosystem resources. The research team appears to be aware of these needs in its planning to support the implementation of a basin plan. In this sense, drawing from the literature on IWRM would be important to understand which mechanisms have or have not worked in similar cases.

Sustainable floodplain lake management: conserving macrophyte biodiversity and ecosystem services, Biosphere Reserve Lobau, Austria

In this urban water reserve, the main problem seems to be how to preserve the water macrophyte flora established in this wetland area since the 19th century. The reserve is currently under stress because of "increasing deposition of suspended solids and plans to use the area as flood diversion and retention channel that could destroy the area's delicate ecosystem. One way social science could be integrated in this project by valuing this rich biodiversity in terms of environmental services. This valuation could be used both as an economic tool and potentially as a subsidy for an education campaign to save the reserve One suggestion would be for the research team to get acquainted with the approach used by the Millenium Environmental Assessment to carry out similar research.

Creation of a Biosphere Reserve to prevent decline in the unique subtropical river floodplain biodiversity, Paraná Floodplain, Brazil

This demosite has already developed a significant level of interaction with stakeholders and carried out outreach activities that could be leveraged into a well-developed IEA. The assessment could, for example, include preliminary studies on the viability of implementing environmental services valuation—and exploring their potential ecological benefits—of different water uses in the basin. Another area where social science could be instrumental is in the investigation of how Brazil's water reform is shaping water management in basin, especially focusing on the interaction with protected areas, and how the focus on IWRM may affect current water use patterns including the dominant role of hydroelectricity and its insulated decision-making organizations. Finally, one specific application of social science could be the investigation of the different ways of improving the socioeconomic and environmental sustainability of fisheries in the basin. Among the various human activities related to the region, improving the income of professional fishery has been identified as a high local priority of the demonstration project. While promoting only one industry avoids conflict among different activities, increasing the level of activity of professional fishery should take impacts on resource conservation into account. Increasing fish stock or / and price are the possible strategies to support professional fishery. Fishery price can be increased by subsidy without affecting consumers directly. If subsidies are introduced, one should pay attention to the possible increase in fishery harvest due to the increase in the price. Carrying out an integrated assessment study that includes both socioeconomic factors (pricing/sustainable livelihoods) and biophysical considerations (conservation of fish stocks) could be a good alternative for this demo site. Another interesting focus could be a study to understand the role of lay and technical knowledge in the management of fisheries in the demo site. This kind of study could inform the implementation of programs to encourage sustainable fisheries practices, for example.[6]

Application of ecohydrology and phytotechnology for water resources management and sustainable development, Pilica River, Poland

There are mainly three issues that relate to socioeconomic aspects. First is the health hazard resulting from eutrophication of the river-reservoir system and toxic cyanobacterial blooms. The susceptibility of different socioeconomic groups should be identified and measurements should be carried out to inform public policy. The second point is river and reservoir pollution by non-point source effluents (sewage, storm runoff, and unsound agriculture and forestry practices). Market-based incentive instruments could be introduced to remedy the situation. Institutional and behavior assessments can be carried out to understand drivers of pollution as well as the opportunities and constraints for the implementation of different kinds of solutions. A well-designed intervention plan would have the added benefit of providing employment opportunities, allowing industry expansion while keeping water quality under control.

Sustainable estuarine zone management for control of eutrophication, toxic blooms, invasive species, and conservation of biodiversity, Guadiana Estuary, Portugal

The reduction of water availability and quality due to the development and production at upper catchment affects tourism, traditional uses such as saliniculture and coastal fisheries in downstream estuary. In order to improve the production in the estuary, this project focuses on water quality improvement, freshwater inflow monitoring, and dam management at upper catchment. One critical problem identified is urban and industrial expansion and their impacts on the estuary. Market-based incentive instruments can be introduced to mitigate negative impacts. Another application of social science could be in the understanding of degradation drivers to inform the design and evaluation of different intervention options. In addition, vulnerability mapping among different water users and better understanding of stakeholder needs can be carried out to inform future policy-making.

---

[1] For a detailed description of the UNESCO’s Ecohydrology Programme, see http://typo38.unesco.org/en/ecohydrology.html

[2] This section is significantly informed by Pierce 1998 and Lemos and Morehouse 2005.

[3] Lemos and Morehouse (2005: 58) define iterativity as “(a) the extent to which the interactions between scientists and stakeholder participants influence how scientists pursue science and how stakeholders understand the possibilities and limits of science, (b) the range of uses to which the scientific knowledge may be put, and (c) the practical value of such knowledge”.

[4] Adopted by the World Summit on Sustainable Development in Johannesburg in 2002

[5] For a comprehensive assessment of the application of social science to an array of water related issues, see {UNDP, 2006 #5}

[6] For an example of an interesting article focusing on a similar theme, see Murray, G., Bavington, D. and Neis, B. 2005. 'Local Ecological Knowledge, Science, Participation and Fisheries Governance in Newfoundland and Labrador: A Complex, Contested and Changing Relationship', in T. Gray (ed.), *Participation in Fisheries Governance*, London, UK: Kluwer Academic Press.

Cited references:

Bauer, C. 2004. 'Results of Chilean water markets: Empirical research since 1990', *Water Resources Research*, 40(W09S06): 11 pages.

Brannstrom, C., Clarke, J. and Newport, M. 2004. 'Civil society participation in the decentralisation of Brazil's water resources: Assessing participation in three states', *Singapore Journal of Tropical Geography*, 25(3): 304-21.

Forester, J. 1999. *The Deliberate Practitioner: Encouraging Participatory Planning Processes*. Cambridge, MA: MIT Press.

Freeman, A. M. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington D.C.: Resources for the Future.

Gibbons, M., Limoges, C., Nowotny, H., Schartzman, S., Scott, P. and Trow, M. 1994. *The New Production of Knowledge*. London, UK: Sage Publications.

Gleick, P. H. 2000. 'The Changing Water Paradigm A Look at Twenty-first Century Water Resources Development', *Water International*, 25(1): 127-38.

Hiwasaki, L. and Arico, S. 2007. 'Integrating the social sciences into ecohydrology: facilitating an interdisciplinary approach to solve issues surrounding water, environment and people', *Ecohydrol. Hydrobiol.*, 7(1): 3-9.

Keeney, R. 1992. *Value Focused Thinking*. Cambridge, MA: Harvard University Press.

Latour, B. 1999. 'From the World of Science to the World of Research?' *Science Magazine*.

Lemos, M. C. and Agrawal, A. 2006. 'Environmental Governance', *Annu. Rev. Environ. Resour.*, 31: 297–325.

Lemos, M. C. and Morehouse, B. 2005. 'The Co-Production of Science and Policy in Integrated Climate Assessments', *Global Environmental Change*, 15(1): 57-68.

Lemos, M. C. and Oliveira, J. L. F. 2004. 'Can Water Reform Survive Politics? Institutional Change and River Basin Management in Ceará, Northeast Brazil', *World Development*, 32(12): 2121-37.

Lindblom, C. 1959. 'The Science of "muddling Through"', *Public Administration Review*, 19(2): 79-88.

Murray, G., Bavington, D. and Neis, B. 2005. 'Local Ecological Knowledge, Science, Participation and Fisheries Governance in Newfoundland and Labrador: A Complex, Contested and Changing Relationship', in T. Gray (ed.), *Participation in Fisheries Governance*, London, UK: Kluwer Academic Press.

Odell, C., Scoble, M. and al., e. 2007. 'Indicators of Socio-Environmental Sustainability in Communities Neighbouring Mines'.

Ostrom, E. 1990. *Governing the Commons*. Cambridge: Cambridge University Press

Peirce, M. 1998. 'Computer-Based Models in Integrated Environmental Assessment', in P. G. Meozzi (ed.), *Technical report no. 14*: European Environment Agency.

Robin, G. 2000. 'Using stakeholder values to make smarter environmental decisions', *Environment*, 42(5).

Scott, A., Skea, J., Robinson, J. and Shove, E. 1999. 'Designing 'interactive' environmental research for wider social relevance', 12 pages. Brighton, UK: Economic and Social Research Council/Global Environmental Change Programme.

Strang, V. 2006. 'Social ecohydrology: an integration of the social and natural sciences', *Department of Anthropology, University of Auckland*, Auckland.

UNDP 2006. 'Beyond scarcity: Power, poverty and the global water crisis', in K. Watkins (ed.), *Human Development Report*: United Nations Development Programme (UNDP).

UNESCO 2005. 'Consultative workshop: Towards integrating social & cultural aspects into ecohydrology', 7. Paris: International Hydrological Programme (IHP). Man and the Biosphere (MAB).

Weiss, C. 1995. 'The Haphazard Connection: Social Science and Public Policy', *International Journal of Educational Research*, 23(2): 137-50.

Weiss, C. H. 1978. 'Improving the Linkage between Social Research and Public Policy', in L. E. Lynn (ed.), *Knowledge and Policy: The Uncertain Connection*, 23-81. Washington, D.C.: National Academy of Sciences, 1978.

Wester, P., Merrey, D. J. and deLange, M. 2003. 'Boundaries of consent: Stakeholder representation in river basin management in Mexico and South Africa', *World Development*, 31: 797-812.

Zalewski, M. 1997. 'Ecohydrology. A new paradigm for the sustainable use of aquatic resources', 58. Paris: IHP UNESCO.

Appendix A: Contributions from Environmental Economics

1. Potential contribution from environmental economics to ecohydrology studies

Environmental economics offers methodologies to assess values of environmental goods and services and provides the designs of economic incentives for adjusting human behaviour. First, evaluation issues such as the value of wetland, the overall impacts of building a dam are often one of the concerns in research on ecohydology. Economic evaluation offers techniques to serve this need. We explain the domain of the value that environmental evaluation techniques can measure in the first section. Secondly, we introduce market-based incentive instruments applied to adjust individual decisions.

Economic value. Three types of approaches have been developed in order to estimate values. The first is the market value approach. This approach offers techniques that value the change-in-productivity, the change-in-income, the replacement-cost, preventative-expenditure, and relocation-cost. The second is the surrogate market approach. This approach offers techniques in terms of valuing the travel-cost, change-in-property-value (hedonic method), wage-differential, and proxy-good. The third is the simulated market approach. This approach estimate values via contingent valuation, trade-off games, contingent ranking and contingent rating, and priority-evaluator.

An economic value to the current generation in this paper refers to the sum of use value and non-use value. In mathematics, this is expressed as the following:

$$\text{Economic value} = \text{use value} + \text{non-use value} \tag{1}$$

Use value is easier to obtain as long as there is a market or price for the goods and services. Non-use value can be estimated using the following equation:

$$\begin{aligned}\text{Non-use value} &= \text{existence value} + \text{vicarious value} + \text{option value}\\ &\quad + \text{quasi-option value} + \text{bequest value}\end{aligned} \tag{2}$$

Non-use value attempts to cover all the functions that environmental goods or services can provide, including their existing and potential functions and the value of leaving choices for future generations. Existence value represents the value obtained from the knowledge that an environmental resource exists. Vicarious value shows the value obtained from the indirect consumption of an environmental resource. Option value is the value obtained by retaining the option to use an environmental resource at some future date. Quasi-option value shows the value enhanced from the opportunity to get better knowledge or technology by delaying a decision that may result in irreversible environmental loss. Bequest value is the value that the current generation obtains from preserving the environment for future generations. There has been extensive research on developing theories and techniques in order to estimate these values (Freeman 1993). Most of them are based on survey methods related to these values. The main controversy in these methods is in deciding on the ‘correct’ values for environmental goods and services.

There are two options for presenting the values: either in terms of different available data (e.g., monetary, energy, and land) or converting into monetary value. Estimation of a dynamic equilibrium that presents both value (price) and scarcity (quantity) may provide a solution. For instance, in the system of environmental and economic accounting for water resources (SEEAW), both monetary and physical terms are represented in a hybrid account (United Nations Statistics Division, 2006 #0). In dealing with uncertainty, applying either expected value or minimum-maximum range can be considered.

Market-based incentive instruments. Market-based incentive instruments can be applied to internalise environmental externalities in a decentralised way. The idea is to ensure those who benefit from using environmental goods and services pay those who provide these good and services. In the context of ecohydrology, these instruments might be helpful to influence the quantity, quality and timing of water flows via upper catchment management, land use management, forest maintenance, wetland conservation, water pollution control, biodiversity conservation, and hydrological extremes mitigation. There are three instruments in general: tax, subsidy and tradeable permits (Baumol and Oates, 1988; Perma *et al.*, 1999). Knowledge about the value of the environmental goods or services would be helpful to set the rate of tax or subsidy and quantity target or tradeable permits.

First is environmental tax. It basically turns environmental costs into taxes or fees. It imposes a tax on less environmentally friendly activities, such as pollution, in order to discourage this sort of activities. The tax intends to bring private costs in line with the social costs. By imposing an environmental tax, the price of the targeted activities would be higher. Then, related individuals such as firms would have more incentives to either decrease these activities or investing in abatement. In the context of ecohydrology, the applications include taxes on water emission level, fees on water usage, and charges on pollution activities such as mining. A tax system encourages targeted individuals to choose a cost-effective allocation on their resources or activities. However, this would only work on the rate of tax is effective. A low tax rate might not have sufficient impact but generating revenue for government.

The second is environmental subsidy. It is any form of intervention which lowers the cost of a targeted activity, or raises the price received by the activity-related individuals, compared to the cost and price that would prevail in an undistorted market. With respect to ecohydrological research, paying upstream land owners to maintain upstream forest and habitat, farm subsidy, and subsidy for applying or developing renewable energy like hydropower are concerned. A subsidy system can combine other social targets such as poverty alleviation and encourage related technology improvement. However, it tends to encourage the activities that are subsidised. If these activities have negative environmental impacts, then the subsidy itself would exacerbate those harmful impacts.

The last one is tradeable permits. A tradeable permits system attempts to secure the quantity and allows efficiency improvement to occur via price adjustment. Take habitat trading for instance, the authorised losses of wetlands and other waters are offset by restored, enhanced, or created wetlands and other waters that replace those lost acres, functions and values. The market mechanism would help to select the wetlands and waters with higher efficiency to offer. Apart from habitat trading, water trading, transferable development rights, and tradeable flood permits are also the possibilities.

Despite of securing both environmental quality and efficiency, a tradeable permits system is often criticised with its substantial transaction cost.

Appendix B: Contributions from Anthropology

Ethnographic mapping and decision making. Conducting ethnographic research in all demo sites is justified on the grounds that the study of cultural ecology of human-water interactions may provide ecohydrology demo sites with a broad understanding of the multiple and complex web of social, political, and cultural variables that underlie human decisions affecting the ecosystems that regulate water cycle. This is also a preliminary step required to understand both economic and non-material objectives that societies have when using water. As noted by Veronica Strang (2006: 3) one first reason to incorporate ecological anthropology at this stage in the demonstration sites "is due to its particular analytic approach, which is located at a 'grassroots' ethnographic level, and involves in-depth research, the collection of empirical data, and close engagement with cultural groups and their everyday activities and forms of production. In this sense, it is intrinsically inclusive of ecological issues, which are central to the immediate material world with which people interact". This perspective is fully compatible with the holistic aim of ecohydrology.

A second reason for incorporating as a first step ethnographic research and ecological anthropology analysis in all sites is its potential to illuminate epistemological disjunctions between the dualistic perspective of western sciences that separates natural from cultural system and native epistemologies that may not do so (Strang 2006). As noted in the previous discussions concerning research models, it is this kind of insight that may yield the incentive to engage science in the "collective experiment" of asking research questions from within society.

A third reason to highlight the value of ethnographic research at this stage is that it may also be used to inform the design of culturally sensitive participatory monitoring systems that assess how decisions affecting the use of fresh water systems relate to household measures of wellbeing. Ethnographic research maybe coupled with Value Focused Decision Analysis (Keeney 1992) to map how people value their natural resources not only in monetary terms. By incorporating ethnographic research, research grams at the sites may gain understanding of core cultural values (fundamental objectives), differentiated from other intermediate objectives that are means to achieve fundamental values or objectives affecting the use of natural resources (Odell, Scoble and al. 2007).

Ethnographic mapping and ecological anthropology studies at the sites will describe human-environment relationships specifically related to water, organizing these textual narratives by means of heuristic categories (beliefs and values, social organization, economic organization and production systems, governance and legal systems), interpreting the meanings that people encode in water in association to all these categories and explaining how these translate into cultural practices in relation to water (Strang 2006).

Deep ethnographic description and analysis of meanings and practices provide groups of interacting researchers and policy makers at sites with the minimal insights required to organize structured deliberation and to design socially effective mechanisms to incorporate technical knowledge into decision making so that public participation becomes meaningful and effective (Robin 2000). Considering that research at the demo sites has not yet reached the stage of actively engaging decision makers, a first application of public consultation as described here could be restricted to defining the research question. Using as reference ethnographic descriptions as described above, the research team will be aware, among other issues, of power relations among stakeholder groups; the history of use, competition, conflict or cooperation among different groups affecting the resource system under study; the different criteria or value systems by which people rank good and bad. In short, ethnographic mapping provides the first clue to understand what water means to different groups of people, and how people perceive and act on the risks associated with its "good" or "bad" management.

At this early stage of incorporating social sciences, sites interested in the construction of mechanisms to incorporate technical knowledge effectively into public deliberation of policy decisions affecting their environment may find useful to apply Value Focused Decision Analysis to identify indicators that matter to people, assess historic impacts and proposing prospective alternatives. As described by Carol Odell et. al 2007: 9

> "VFDA is a rational decision-making process based on the concept of multi-criteria analysis using carefully designed interview techniques to identify a clear set of values and objectives from which a concise series of measures (indicators) is designed. These indicators are then used to drive the selection of alternative projects and development strategies and in assessing the trade-offs between alternatives until acceptable alternatives can be identified."

This methodology relies on ethnographic techniques to elicit and map the relationships perceived between benefits, impacts and group values and objective according to local cultural categories. Through a set of iterative open questions ("What do you mean by…?") which explore further the nature and meaning of those relationships, it is possible to isolate fundamental aims of the group from aims that are means to achieve the fundamental goals. Once this structure of objectives has been elicited and validated it is possible, also by means of participatory tools, to construct indicators that measure performance of the systems that yield results for the objectives hold important by the group. Mapping these objectives and organizing indicators may in fact provide researchers with a preliminary chart to design their studies and negotiate inter disciplinary research questions. Following the learning cycle described in the section focusing on the creation of usable science, socially legitimate indicators can be used to (*i*) integrate technical knowledge arising from ecohydrology research into public-informed policy decisions that affect human-nature relationships, (*ii*) assess the end results of such decisions from the perspective of resource users; and finally (*iii*) improve research questions and consultation mechanisms at the site.