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Integrating the social sciences into ecohydrology: facilitating an interdisciplinary approach to solve issues surrounding water, environment and people

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Abstract

This paper identifies and outlines some issues that need to be addressed in order to integrate the social sciences into the current work on ecohydrology. In an attempt to overcome the gap that currently exists that ecohydrologists have yet to fully deal with the important factor related to people's relationship to water and the surrounding environments the paper emphasizes the need to understand the specific social and cultural dimensions of a given environment in order to define the various and multi-faceted relationships people have with the environment. The paper concludes that bringing together concepts and methodologies from the social sciences will facilitate ecohydrology to move forward as a truly integrated science.

Key words: Social and cultural factors; integrated science, people-water relations.

1. Introduction

Water is essential for life: for the conservation of the environment, for human health and well-being, the alleviation of poverty and hunger, and maintenance of cultures and societies. Sustainably managing this scarce and vulnerable resource is thus a global challenge that needs to be tackled worldwide.

According to the Millennium Ecosystem Assessment, most of the ecosystem services on which human well-being depend are being degraded and lost. Water is one of such services: it supports ecosystem processes (without water many such processes could not take place); in turn, ecosystems are the source of water used by people. Fifty-seven percent and 28 percent of the total water runoff depend, respectively, on forest and mountain ecosystems, which provide water to approximately 4 billion people, or two-thirds of the world's population. In comparison, cultivated and urban systems provide tiny amounts of water runoff (16% and 0.2%, respectively), but serve between 4.5 and 5 billion people inhabiting those areas (Millennium Ecosystem Assessment 2005).

Sustainably managing water resources is a challenging task, because systems, problems and management strategies related to water are shaped by complex interconnections of socio-cultural and biophysical factors. In order to develop policies to manage water resources in a sustainable manner, there is thus a need to understand the specific social, cultural, economic and political dimen-

sions of a given environment in order to define the various and multifaceted relationships people have with the environment. It is also vital to understand people's actions, as well as institutions and governance structures that shape these actions.

In the past, studies and management issues pertaining to water had been studied from hydrological or engineering points of view. However, in order to sustainably manage water resources, it is necessary to integrate several different approaches, across both disciplines and scales. This is because in order to solve the multifaceted problems surrounding water, these problems cannot be compartmentalized into narrow scientific disciplines.

The development of ecohydrology, a new approach in the environmental sciences that promotes the integration of hydrology and ecology for the sustainable management of water resources, constituted a significant step forward in interdisciplinary science. UNESCO's International Hydrological Programme (IHP) and the Man and the Biosphere (MAB) Programme have played an important role in developing and defining ecohydrology, both as a concept and a methodology, since the mid-1990s. Ecohydrology emerged within the framework of the fifth phase of IHP (IHP-V: 1996 - 2001), theme 2: "Ecohydrological processes in the surficial environment" (UNESCO 1996).

The sixth phase of IHP (IHP-VI: 2002 - 2007) has followed up on this through its theme 3: "Land habitat hydrology", which further develops ecohydrology as an interdisciplinary approach at the landform/land use scale (UNESCO 2002). Furthermore, one of the themes in the strategic plan for the seventh phase of IHP (IHP-VII: 2008 - 2013), "Ecohydrology and environmental sustainability", aims to incorporate environmental sustainability at the landscape level by improving our understanding of water-landscape level management of the environment, taking fully into account the interactions among ecosystems and their dependent habitats.

The development of the ecohydrology concept reflects the urgent need for the development and implementation of new and cost-effective methods to improve the sustainability of water, in the face of increasing pressure on freshwater resources. 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. In order to incorporate social and cultural factors into UNESCO's Ecohydrology Programme, there is thus a need to bring together concepts and methodologies from the social sciences.

A review of literature makes it clear that much research has been conducted by social scientists on issues surrounding water and its management. Numerous descriptions and analyses have been conducted on water conservation, use, and management practices that are rooted in traditional or local practices, and beliefs (such as Dixon 2001; Flanagan, Laituri 2004; Gelles, Boelens 2003; Hill, Woodland 2003; Lansing 1995). Ample studies exist surrounding uneven power relations, conflicts and rights surrounding water and its management, such as Blatter and Ingram (2001), Donahue and Johnston (1998), and Verweij (2000). It is thus clear that lack of social scientists is not the obstacle to effective social science integration into studies surrounding water management.

The purpose of this paper is to provide an overview of some issues that need to be addressed in order to integrate the social sciences into the current work on ecohydrology. The paper first outlines the social, cultural and political factors that need to be taken into account in order to consider sustainable management of water resources. Then, some methodologies used in social science research are introduced, which may allow the ecohydrology approach to mesh with a more complete picture of the social and cultural dimensions that surround water. An argument is made for a paradigm shift both conceptually and methodologically necessary in order to integrate social and cultural factors into ecohydrology and sustainable water resource management. The paper concludes that bringing together concepts and methodologies from the social sciences will facilitate ecohydrology to move forward as a truly integrated science.

2. Ecohydrology: definitions

According to Zalewski (2004), ecohydrology is an integrative systemic approach for reversing the degradation of river basin services by regulating hydrological and ecological processes thereby enhancing the capacity of ecosystems to absorb adverse impacts. The three hypotheses of ecohydrology are: (1) regulation of hydrological processes can generally regulate biological processes; (2) biological processes can be shaped as a tool to regulate hydrological processes; and (3) these two types of regulations (1 & 2) can be integrated with hydro-technical infrastructure to achieve sustainable water and ecosystem services (Zalewski *et al.* 1997). The key element of ecohydrology is its use of dual regulation to provide "low cost - high technology" solutions by enhancing ecosystem carrying capacity against anthropogenic stresses to complement technical solutions,

in order to achieve sustainable river basin management (Zalewski 2006).

The above definition is the one that emerged within the framework of UNESCO's IHP. It should be noted, however, that as with any new and emerging concepts, there are multiple interpretations and usages of the concept in the larger scientific literature.

Rodriguez-Iturbe (2000) defines ecohydrology as the science that seeks to describe the hydrological mechanisms that underlie ecological patterns and processes. He focuses on the processes in which soil moisture is the key variable that modulate the complex dynamics of the climate-soil-vegetation system and that control the spatial and temporal patterns of vegetation (Porporato, Rodriguez-Iturbe 2002).

Nuttle (2002) argues that the term ecohydrology encompasses diverse ideas at the interface between hydrology and ecosystem science. Building on the works of Zalewski and Rodriguez-Iturbe, Nuttle suggests that ecohydrology is a sub-discipline shared by the ecological and hydrological sciences that is concerned with the effects of hydrological processes on the distribution, structure and function of ecosystems, and on the effects of biotic processes on elements of the water cycle (2002).

Ecohydrology is also seen as a very important element of "interactive hydrology", whose development and practical application are of primary importance to sustain the humans in harmony with the environment (Kundzewicz 2002).

According to Falkenmark and Rockstrom (2004), ecohydrology has to address the fact that managing water for the future can only be achieved by integrating water for humans and nature; therefore, there is a need for an integrated approach to water for socio-economic development while at the same time safeguarding vital ecosystems.

The brief overview presented above does by no means intend to give a complete picture of ecohydrology, both as concept and management approach. It does, however, highlight the need for a consolidated definition of ecohydrology, as well as demonstrate the possibilities that the ecohydrology approach harbours for further integration. The two important characteristics of ecohydrology that will be highlighted for the purposes of the discussion in this paper are:

- a concept and an approach that link ecology with hydrology in order to consider interactions between water resources and ecosystems and thereby provide solutions to issues surrounding water management; and
- an interdisciplinary, integrated and holistic approach to sustainable management of water resources, targeting a wide range of ecosystems[1].

3. Social and cultural factors of water

Defined simply, social and cultural factors of water can be encapsulated to mean people's relationship to water and the surrounding environments, in particular, people's environmental beliefs and values. Institutions and governance structures that shape people's actions are also integral to understanding the complex interaction between people and their surrounding environments. In order to integrate such factors into the science surrounding sustainable water resource management, in particular ecohydrology, a shift in paradigm is called for one that changes the framework under which water-people interactions have been viewed by hydrologists, ecologists and ecohydrologists alike. Such a shift in paradigm would imply shifts in two aspects: conceptually and methodologically.

Conceptually, there is a need to look beyond water-people interactions simply as human drivers of change that is, that of use (i.e., water consumption for drinking, agriculture, sanitation, etc.) or as pressure (e.g., sewerage, industrial pollution, change in land use etc.) on water resources. In fact, there is a need to understand the specific social and cultural dimensions of a given environment in order to define the various and multifaceted relationships people have with the environment (in this case, water and associated ecosystems), in addition to the mere understanding of the environmental context *strictu senso*. To fully analyse these relationships, it is necessary to move away from a dualistic framework of thought that separates "the environment" with "people" (and their cultures); rather, a holistic conceptual model must be adopted, one that allows one to look at human-environmental relations as mutually constitutive (Descola, Palsson 1996).

It is important to note that most landscapes in the world, including water-based ecosystems and landscapes, are "biocultural" landscapes, i.e., a blend of natural processes and human culture, which mutually affect each other. If properly planned and executed, such interactions will have a positive and synergistic effect (Bridgewater, Arico 2002).

[1]According to di Castri and Hadley (1986), *multidisciplinary* efforts involve several discplines, with little or no interaction or cooperation among them; *interdisciplinarity* implies interactions and coordination among the different disciplines involved; and *transdisciplinarity* consists of interactions that involve not only the scientific disciplines, but also local people and other stakeholders, such as water managers and administrators.

Conceptually and methodologically, it is important to note that social issues cannot be simply inserted into already-existing frameworks that have been defined by hydrologists, ecologists or ecohydrologists; rather, a true shift in the conceptual and methodological approaches to integrated water resource management will be possible only if social scientific perspectives are fully integrated from the very beginning. Moreover, there is a need for equality between the social and natural sciences, not just in considering theoretical frameworks, but also in formulating research questions and designing research projects (Strang *in press*), as well as in collection and analysis of data.

The social contexts

The human use of water resources has been increasing at the rate of 20 percent per decade since the 1960s. Due to urban and production activities, water quality is affected by nutrient (inorganic) and industrial pollution on a large scale (inorganic pollution has increased tenfold in many industrialized parts of the world). More than one billion people meet part of their need for water through the extraction of groundwater supplies, and in certain regions of the world such as North Africa and the Middle East, unsustainable use of water resources amounts to one-third of all water use. The use of water for agriculture is estimated to be unsustainable worldwide. Construction of large dams, while intended to help optimize the management of water resources, has resulted in negative impacts on freshwater ecosystems. Moreover, not only have the costs of constructing large infrastructures for management of water resources generally been underestimated, but also their benefits have been overestimated and not shared equitably, which has had adverse social effects (Millenium Ecosystem Asessment 2005).

Changing lifestyles and consumption patterns, in particular increased leisure activities such as tourism, have led to greater water demands as well as pollution due to sewerage problems, especially in ecologically fragile areas.

In terms of scenarios, water withdrawals are likely to decrease in OECD countries because of saturation per capita, better efficiency in the management of water resources and stabilizing demographics. The projected trend in the rest of the world indicates likely increases in water withdrawals as a result of economic development and population growth. Globally, the use of water between 2000 and 2050 is expected to increase between 20 percent and 85 percent; but as global water availability will also increase, in principle there will be enough resources to meet such a demand (Millennium Ecosystem Assessment 2005).

The cultural contexts

Management of water depends to a high degree on local social and cultural systems for its sustainability. In order to appreciate the close interlinkages between water and social, economic, political and cultural processes, it is thus important that these diverse systems, as well as the important role water plays in the maintenance of production systems with social and cultural significance, are well-understood.

For the sake of analysis, the issues surrounding water and culture can be divided into three main areas of concern. The first area includes the cultural systems and traditions that govern or contribute to the conservation, use and management of water and related resources. These are rooted in traditional/local/indigenous value systems (i.e., religion, worldviews and beliefs), knowledge and customs. The second area includes the traditional/local social institutions that govern water management. In many societies, the management of water for agriculture (e.g., irrigation) is an exercise in social cooperation, in which traditional authorities or practices make such social coordination possible. The third area concerns cultural practices that depend on conservation of water and related resources for their existence and expression; water often plays an important role to maintain production of food used in rituals, festivals and other special occasions of cultural significance. All these three areas are strongly linked to people's social identities.

When water management moves away from the local level, cultural and social values of water are often lost. This is because, for example, when river management is delegated completely to a national government agency or privatized, the relationship between people and the river becomes less intimate. This not only ignores the diverse relationships between water and culture, but also negatively affects people's sense of stewardship. Furthermore, such acts as centralization and privatization often adversely affect the relationship between water users and water managers or owners.

It is thus clear that strong and numerous links exist between water use and culture and these links need to be maintained, strengthened and integrated into water management policies and plans at all levels in order to bring about effective management of water resources. Instead of basing water management on a conceptual model that separates people and their relationships with water, it is necessary to consider the relationship between people and water as a dynamic engagement in which socio-cultural and ecological factors interpenetrate each other (Strang *in press*).

Political contexts and policy implications

Institutions and policies to manage water resources include: market-based incentives such as damages for exceeding pollution standards; water markets based on reallocation of water resources between irrigation and municipal uses; payments for watershed services (which should encompass the ecological and cultural values of water-providing ecosystems, in addition to the mere value of the water resources being used); partnerships and financing in the re-examination and retrofitting/refurbishment of existing water management infrastructures, including dams, due to their inadequacy in reflecting the high social value of freshwater services; and appropriate wetland restoration programmes. It should be noted that market-based water management systems, which are often considered as more efficient, tend to externalize and thereby ignore both environmental and social costs.

There is an obvious deficiency with regard to defining and ensuring the rights to freshwater services and the responsibilities for their provision. In the case of upland communities, they have generally been excluded from access to benefits. More generally, there is a need for property right systems and clear and transparent rules for their implementation so as to meet stakeholders' needs and expectations and raise their willingness to pay for water services. Mechanisms for increasing the effectiveness of stakeholders' participation in water decision-making are also key. At a large scale, river basin organizations can play an important role to ensure stakeholder participation. However, it should be noted that because such organizations are often led by natural scientists who take very technical approaches, they generally fail to tackle social and cultural dimensions.

In addition to such institutional and regulatory measures as those mentioned above, the main sectors that also have impacts on water management include landscape planning, the conservation sector, protected area designation and management, natural resource management, mining and agriculture. In addition, institutions that influence and define the multifarious relationships between the environment and people which are often overlooked by water managers such as those surrounding regional or community development need also be considered. Such institutions would include those concerning economic activities such as tourism, agriculture and fishe-ries, as well as those concerning community issues such as indigenous affairs. Another aspect of people-water relationships that need to be considered, that would have important implications for policy-makers, is integration of traditional and non-traditional water management practices. Successfully providing policy and institutional support to local and traditional knowledge on water resources, as well as facilitating local community participation in water management, is crucial for sustainable management of water resources.

4. Methodological approaches to integrating social and natural sciences in managing water resources

The ecohydrology approach can potentially be extended to mesh with a more complete picture of the social, cultural, economic and political factors of water. For this to happen, the environmentally deterministic assumption that underlies ecohydrology and the natural sciences in general must be changed: neither hydrology nor ecology determines social behaviour. Although people may behave in response to environmental pressures, they are not bound by them; rather, the interactions between people and the environment are more dynamic. Methodologies used in social science research, such as stakeholder analysis, make it possible to better understand these interactions.

Stakeholder analysis and facilitating local community participation

Identifying the diverse stakeholders involved, examining the differences in political, social, economic and cultural interests, and analyzing the institutional arrangements that structure interactions among the actors are central to social science research. Considering that stakeholders often have very different forms of water use that are not always compatible and are, in fact, often conflicting, such analyses make it possible to gain deeper insight into power relationships and limitations that institutional arrangements and social relationships reflect and engender. This type of information is important for influencing decision-making and formulation of policy and institutional support necessary to facilitate the sustainable management of water resources.

The integral role social scientists can play in facilitating participation of different stakeholders, including local communities, in water resources management should also be recognized. The process of gathering qualitative data enables social scientists to interact closely with various stakeholders including government entities, industries, domestic water users, local communities, recreational water users, non-governmental organizations and the academia and facilitate their participation.

Issues of scale

Social scientists tend to work at different temporal as well as spatial scales than those in which

natural scientists work. In terms of temporal scale, social science research generally requires far more diverse types of data most notably in-depth qualitative data than is commonly used in natural science research. Therefore, more time is necessary to collect and analyse such wide range of data, through participant observation and lengthy interactions with informants (Strang *in press*). In addition, articulation of complex social and cultural issues, such as by examining stakeholder interests and social institutions, necessarily requires analysis over long-term and thus makes it difficult to produce results in the short time framework under which natural scientists often work.

In terms of spatial scale, the catchment focus of ecohydrology and integrated water resource management is often a limiting factor for social science research. The unit of analysis for social scientists varies greatly, but in cases where different ethnic groups or communities use a river basin, for example, the scale often needs to be much larger than just the catchment. Catchment areas can be a feasible scale for social science research only when sufficient time is built in to enable ethnographic research with each of the diverse range of water user groups, as well as research on their interactions.

According to IHP-VI theme 3: "Land habitat hydrology", ecohydrology is developed as an interdisciplinary approach at the "landform/land use scale". This seems to suggest a landscape-based approach to the integrated study of water-related issues; however, so far, most of the issues have been framed by both ecologists and hydrologists, as well as by ecohydrologists, in the catchment scale.

Conclusions

As outlined above, as an approach, ecohydrology harbours possibilities to incorporate social and cultural factors, as well as having the significant potential to promote dialogue and collaboration among stakeholders. Up until now, however, it has for the most part ignored the critical contribution of the social sciences to the understanding of water use and management at diverse scales of governance. In consequence, fundamental aspects of social, cultural, political and economic interactions affecting water use and conservation have been virtually absent from the ecohydrology approach. In order for this ecosystemic approach to water management to reach its full potential, the need to integrate the social sciences should be recognized and activities organized to increase communication and cooperation to promote broader interdisciplinarity.

With this understanding, the future work of UNESCO's Ecohydrology Programme will work towards addressing these issues by, inter alia, emphasizing the importance of social, political, economic and cultural factors in water sciences and sustainable water management, which would enable a holistic understanding of the context of water use and management; understanding the importance of studying different and competing value systems concerning water and landscapes; and exploring more deeply institutional and governance aspects of water use and management. A Task Force on Ecohydrology and the Social Sciences, which was officially established in May 2006, will play a key role in this process of integrating the ecohydrology concept with the social sciences. The ultimate goal is to move ecohydrology forward as a transdisciplinary approach to the solving of issues surrounding water, environment and people.

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