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Conceptual PHES-system models of the Aysén watershed and fjord (Southern Chile): Testing a brainstorming strategy

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Abstract

The use of brainstorming techniques for the generation of conceptual models, as the basis for the integrated management of physical–ecological–social systems (PHES-systems) is tested and discussed. The methodology is applied in the analysis of the Aysén fjord and watershed (Southern Chilean Coast). Results show that the proposed methods can be adequately used in management scenarios characterized by highly hierarchical, experts/non-experts membership.

Keywords: Conceptual models; Stakeholder's participation; Integrated management; Brainstorming

1. Introduction

The explicit incorporation of *Homo sapiens* as a component (and stakeholder) of earth's ecological systems is an unavoidable result of our influence on almost every corner of our planet. However, classical ecological concepts (e.g. communities, ecosystems) do not allow for the straightforward incorporation of human society and economy (O'Neill, 2001). With this problem in mind we generated the physical–ecological–social system (PHES-system) concept as a way to incorporate constructivist ideas into ecological analysis (Marín and Delgado, 2005). A PHES-system is a spatially explicit ecological system for which limits and components (with the exception of human societies that by definition belong to every PHES-system) depend upon the questions being asked and the people that ask them. The concept falls within moderate or contextual constructivism (Jones, 2002), where diverse worldviews would correspond to different interpretations of a common reality. The role of scientists in this view of nature has been clearly defined by Kay (2001): "In post-normal science, the scientist's role shifts from inferring what will happen … to providing decision makers and the community with an appreciation of how the future might unfold". However, there may be as many PHES-systems for a given ecosystem (*sensu stricto*) as groups of stakeholders, all of them equally legitimate and even occasionally incompatible (Ludwig, 2001). Furthermore, the integrated management of any ecological system requires that all involved stakeholders reach agreements regarding their components, limits, pressures, states and societal responses. Thus, many strategies have been designed to generate such agreements (Cundill et al., 2005; Theobald and Hobbs, 2002; Heemskerk et al., 2003; Chermack, 2004; Burt and van der Heijden, 2003; Mysiak et al., 2005). The development of conceptual models is one strategy we have employed when dealing with the need to make our ideas explicit to other people (Delgado and Marín, 2001; Marín and Olivares, 1999).

Although conceptual models can be effective communication tools, their development in interdisciplinary environments is difficult due to, in part, language differences among experts (Heemskerk et al., 2003). Furthermore, if the range of stakeholders involved in the creation of the conceptual model is too broad, then the possibility of inhibition of certain groups of people, especially in highly hierarchical settings (e.g. students–professors; land owners–peasants), is highly likely. Thus, we

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felt that a more uncritical environment should be engendered prior to the generation of conceptual models. In such an environment, the focus should be on reducing inhibitions, so that people express their points of view in a more open manner. Nicolson et al. (2002), working to develop heuristics for interdisciplinary modeling, point out that the task of communicating with stakeholders is vastly underrepresented in many scientific projects. The strategy we have developed has been oriented to solve this problem and to go one step beyond. That is, to incorporate stakeholders within the modeling team. This is rather timely, because as pointed out by Freudenberg and Alario (1999): real world decisions involve not only facts but a combination of facts, values and blind spots. Furthermore, the incorporation of stakeholders within the modeling group increases their awareness of the ecological conditions upon which they exist. This contributes to the integrated management of ecological systems. Thus, we need to widen our modeling teams to allow the interaction of experts and non-experts. In what follows we describe an academic exercise designed with the purpose of testing the strategy we have devised to develop conceptual models of a watershed-fjord system in Southern Chile (Aysén). Participants for this exercise belonged to local government organizations related to environmental issues, undergraduate and postgraduate students from environmental curricula and university professors.

2. The ECOManage project

The ECOManage project (Integrated Ecological Coastal Zone Management System; http://www.ecomanage.info), is a research initiative financed by the European Union as part of the Sixth Framework Program. Its main aim is to push the capacity of assisting managers in the integration of knowledge derived from ecological and socio-economic disciplines. The three key aspects of ECOManage are: (1) the consideration that a coastal zone depends not only on local pressures, but also pressures originating in the drainage basin, transported mostly by rivers and by groundwater, (2) that socio-economic activities are the driving forces of those pressures and that their impacts on the ecosystem have feedback on socio-economics, and (3) the impacts depend on physical characteristics of the ecosystem that together with the loads determine its ecological state. Three coastal zones showing conflicting interests between urban, industrial and agricultural pressures and environmental maintenance have been selected for developing the system. The selected areas are: Aysén Fjord in Chile, Bahía Blanca estuary in Argentina and Santos estuary in Brazil. ECOManage is based on the generation of strong interactions with stakeholders, in order to establish study scenarios and to measure the environmental impacts of management decisions. The project is being carried out by a highly diverse group of specialists from ten institutions in six different countries from both Europe and South America. Thus, from the very beginning there has been a clear need to generate innovative participatory methods, both among project partners and between partners and stakeholders.

3. The Aysén fjord in Southern Chile

Chile is a South American nation located in the eastern South Pacific. The country is politically divided in thirteen regions from North to South. The Aysén region is located between 43°38′S and 49°16′S, within the Sub-antarctic domain. Although this region comprises 14.2% of the Chilean territory ($109 \times 10^3\,km^2$), it hosts only a 0.8% of the country's total population with 91 492 inhabitants (INE, 2002). Indeed, in 1907 the population in the area was of only 197 people (Ortega and Brünning, 2000). Most of today's population (80%) lives in two counties (Aysén and Coyhaique) located within the Aysén watershed which drains into the Aysén fjord (Fig. 1). The original population of the area was composed of two ethnic groups: Tehuelches and Alacalufes. These groups are currently nearly extinct in the region, with the exception of a 0.3% of the population that associates themselves to the Alacalufes. Nevertheless, an 8.4% of the population state that they are Mapuches in origin (INE, 2002).

The environmental history of the region includes an unfortunate episode where human colonization was accomplished using fire (Ortega and Brünning, 2000). The resulting wildfires—which burned throughout the 1940s—have left a long-lasting mark on the Aysén region. The fires were started intentionally by settlers (and supported by the governmental policies of the time) to clear areas for cattle and sheep. However, they went out of control, burning freely in the summer months and smoldering underground during the winter. This long-term and subterranean burning has affected the soils of the region in terms of organic content as well as chemical and physical properties. In total 1.5 million hectares were burned. This legacy is still affecting the development of the region, since any increase in agribusiness will require external fertilizers.

Table 1 shows the top ten exports of Aysén for three recent years. Eight of these are related to fishing and aquaculture; the remaining two are from the mining and forestry sectors. The main sources of environmental conflicts in the area are related to water quality, both within the watershed and the fjord of Aysén. Salmon farming requires clean waters, which in turn generates restrictions to the industrial development within the watershed. Local fishermen, on the other hand, complain that salmon farmers are located in shallow areas where they used to fish and that their income has decreased in recent years. Furthermore, there are complains from the tourism industry that salmon cages degrade the "pristine scenic beauty" which it sells. All these conflicts are important to solve since a governmental study, conducted as part of the ordination of the Aysén territory (http://www.planregional.cl/portal/), has shown that the economic