**Olivier Barge, Thierry Joliveau & Crane Rogers**
C.R.E.N.A.M./C.N.R.S. U.M.R. 5600
Université de Saint-Etienne,
6 rue Basses des Rives, 42000 Saint-Etienne, France.
Tél.: 04 77 42 19 25. Fax : 04 77 42 19 24
crenam@univ-st-etienne.fr

# *Values of water and aquatic ecosystems : for a territorial approach to participatory planning*

**Abstract** : Most European countries have shifted from traditional water management to comprehensive management and on to environmental water management. In France, the 1992 Water Act provides new planning procedures that are to enable a long term balanced between user demands and conservation objectives. These tools are based on spatial representation of management stakes, leading to a model that combines ecosystem description with resource uses and stakeholder values. Difficulties in applying this new procedure have made clear the need for new approaches to clarifying stakeholder perceptions and transforming them into planning information. This article presents an approach based on defining management territories and objects by delineating ecosystems, resource uses, and stakeholder representations. The perspectives for applying this approach in the form of an operational management information system using G.I.S. as a support are reviewed.

## Introduction

In most traditionally democratic post-industrial societies, increasing consideration has been given to environmental issues in recent years. Within this trend, the accent has been on providing for lasting equilibrium and collective solutions, thereby requiring a change in management principles and procedures. Though it is often taken for granted, water is particularly essential resource to both man and nature, and is a very compelx resource to manage. In France, the reforms introduced by the 1992 Water Act have provided food for thought on the subject of water planning and management methods. In particular, the *Schémas d'Aménagement et de Gestion des Eaux* that is to say 'local water management and development schemes' are to promote environmental conservation while satisfying all forms of water use. Moreover, these planning operations are expected to incite considerable user participation in planning, making it possible to settle on common management objectives. Such procedures will require the collect, analysis, and diffusion of considerable amounts of information, integrating a wide variety of problems and viewpoints to establish a common framework for negotiations.

Our interest here focuses upon information management strategies that could be used to help make this approach operational. A conceptual framework is proposed by which user representations and values may be better accounted for as information for participatory management. The principles developed are illustrated by examples chosen among recent work in France from the C.R.E.N.A.M./C.N.R.S. U.M.R. 5600 research centre, all of which serve to demonstrate the potential of Geographic Information Systems (G.I.S.) in this context. Examples include an approach to river ecosystems assessment on the scale of major rivers basins, (Loire catchment) (Bethemont, *et al.,*1993), an environmental impact evaluation of white water sports on the upper Allier river (O. Barge, 1994) and a conservation assessment study of the Sioule - Allier confluence (O. Barge, 1995).

## Changing management practices and their implications

### *From traditional to comprehensive environmental management*

European states have been directly involved in water management for centuries. Their policies and institutions have evolved in a similar manner over the years, although each country has changed at its own rhythm in relation to specific cultural and political considerations. Traditionally, water was managed in response to sectorial demands, but industrial development, domestic uses, agricultural modernisation, electrical production, etc. have together led to a multi-sector approach, accounting for the various uses of a given water resource as a whole, and the interactions or competition among them. Conflicting and sometimes contradictory objectives have led managers to act as mediators between various stakeholders (Dupont, 1991). Management may thus been seen as a complex system of exchanges between different kinds of participants, in which insufficient communication is a major obstacle to efficient management (Long, 1985) (Fig. 1). As Barraqué (1995) has shown, the fact that flowing water is considered as common heritage in most of these countries has led to proposing increasingly participatory resource allocation procedures in place centralised authoritative ones. Negotiation has become a common practice for solving conflicts and for obtaining compromises agreement among different users within the scope of collective aims.

More recently, the increased attention granted to environmental issues, namely conservation and sustainability, has added to the complexity of comprehensive water management. These events have stimulated work on various aspects of river ecology, leading to the development of new concepts, such as the notion of fluvial hydrosystems (Amoros et Petts, 1993), and new approaches to assessing river ecosystems. For this latter, several desk studies covering the principles and methods proposed have been edited, among which : Frissell *et al*, (1986) Wasson, (1989), Naiman *et al*. (1992), and Kondolf, (1995). The variety of outlooks on water resources has increased, both among experts and public opinion, leading managers and legislators alike to reconsider traditional water management policies and institutions (Boddaert, 1990; Sormail, 1991; Zamuth, 1991; Coulet, 1992). In has become clear that negotiating resource allocation among users no longer suffices. The impacts of various uses upon the environment must be taken into account to conserve and sustain resources in the name of common interests.

### *Adapting mans' actions to environmental equilibrium, or environmental equilibrium to mans' actions ?*

The above mentioned issues have given way to a variety of proposals for ecology oriented water management. Among these, we have chosen to comment on an approach presented by J.-G. Wasson (1992) at the Fourth Jacques Cartier International Congress on environmental management of major river basins. Based upon the fluvial hydrosystems concept, this approach aims to "*(re)integrate mans' actions into nature's equilibrium*". The procedure is divided into four main stages : 1) Diagnosis and perspectives, 2) Defining constraints, 3) Options and scenarios, 4) Identifying choices and actions. Although verification is foreseen at the issue of the first two stages, the procedure leaves little room for adaptation. The stage of defining constraints is seen as being "*central to the entire approach*". A hierarchy of constraints and priorities is defined, to which management options considered in the third stage must comply. A framework for classifying constraints is proposed, opposing socio-

economic and ecological criteria. A given option may not be considered when in opposition to constraints of higher priority, whereas opposing options of equal priority are abandoned or reformulated so as to respect the hierarchy of priorities. Hierarchical classification of management priorities is indeed useful in settling management conflicts and negotiating management options. In this sense, the proposed procedure may be seen as a valuable tool enabling managers to order and arbitrate various projects in light of predetermined general objectives.
Another interesting aspect of the proposed procedure is that vocational priorities are to be defined on the level of specific resource units. A typology of homogeneous resource units is proposed, taking into account the kind of natural ecosystem considered and well as the present state of resource units (original, modified natural, artificial). In this way, river segments may be classified on the basis of their ecological et usage aptitudes in order to establish local vocations. While repeating general constraints, each individual segment is to be attributed a specific vocation ('wild' nature, new or current uses, improved public access, priority to economic uses, etc.). The proposal foresees the need to restore streamway liberty to channel instability where possible, and insists on encouraging 'soft' bio-engineering techniques in an effort to conciliate management objectives. The combination of a general hierarchy of priorities and typologies of aptitude and usage vocation is presented as a means to guarantee both ecological and usage diversity, and thus as a tool for solving conflicts.
However, the proposed typologies described above are presented as being detrained by an objective assessment of ecological processes. The principles of the fluvial hydrosystem concept serve here to establish classifications that would dictate the priorities in managing water resources and their use. As the sustainability of these uses is dependant upon the state of resources, conservation and restoration are in the best interests of stakeholders, and these latter should thus willing accept such measures. As managers are to educate users and explain the importance of these new goals, the co-operation of stakeholders should be easily acquired. The approach is presented as being perfectly objective, as it is based on scientific principles, but this scientific objectivity is only apparent. Without questioning the concepts upon which they are based, the typologies proposed (constraints and environments) are in fact expert evaluations. As in any evaluation, they mix scientific, institutional and social considerations (ROQUEPLO P., 1992) and include subjective reasoning, be it that of respected scientists. In examining expressions used by the author such as "*great ecological value*", "*ecosystem modification*", "*negligible, significant or major modifications*", it is clear that though these terms are linked to objective ecological assessment, they also express a certain point of view on the subject. In spite of their interest, these proposals are in fact not any more objective than traditional top-down management approaches based on economic and technical criteria. As they are based on the values of a specific group (i.e. the scientists that propose them), they can only be considered as another point of view that may be a source of ideas, but which must be considered within the scope of the various points of view involved.

### *The need for a participatory approach*

The idea of basing management exclusively upon scientific principles appears to lead only to a change of evaluation criteria, while remaining otherwise similar to top-down procedures characteristic of technocratic (ecolocratic ?) management. In contrast, the increasingly supported principles of participatory planning and collective ressource management seem to be the best guarantee of essential goals : user satisfaction and environmental conservation.

The first argument for this position is that increasing stakeholder participation in planning would seemingly increase the co-operation and success in applying management directives.

The second and perhaps most crucial argument is that in participatory planning, contrary to top-down procedures, no one usage would be arbitrarily favoured in detriment to others.
By comparison with management in countries where public opinion has little weight, it seems that participation may also contribute to environmental protection. In the democratic societies of western Europe, where traditional management was technocratic, examples of degraded ecosystems concomitant with decreased resource availability are unfortunately not lacking. However, such problems appear moderate by comparison with catastrophic development programmes in non democratic eastern European countries (Marchand, 1992). Without interest groups able to express demands or objections, river development was centred on specific interests of state, often excluding traditional uses. Moreover, the degree of environmental damage caused by these programmes is unknown to western Europe, where potential public opposition has imposed multi-functional and relatively consensual development projects. It would seem then that there is a relationship between the extent of participation in management and the satisfaction of the previously mentioned goals (user satisfaction and environmental conservation). Nonetheless, options, conflicts and choices in management do imply weighting priorities that favour certain uses and penalise others (Bethemont, 1992).

In the 1980's, mangers in France stressed the importance of river maintenance and channel restoration, and it clearly became necessary to involve local communities in these actions through incentive measures and new regulations (Malaval, 1991 ; Sormail, 1991). A regional study of river maintenance shows a strong relationship between the presence of local organisations in charge of maintenance actions and effective regular maintenance, whereas operations in other areas show a lack of co-ordination and ineffective results in spite of increased incentives (Pols et Verne, 1987). A pilot programme for local river management was established, based on an contractual agreement between the state, local communities and local users, in order to co-ordinate restoration programmes on certain rivers. These programmes focused on improving water quality and restoring riverbeds, but also increased local awareness and incited community members to take part in management. The approach was promising, but due to a lack of adequate legislation and management structures, these programmes were unable to provide for permanent lasting river management (Duport, 1991). The studies conducted in these programmes were limited to the technical aspects of river restoration not accounting for socio-economic criteria concerning uses, whereas limited participation of local stakeholders was seen as one of the major weaknesses. The 1992 Water Act attempts to develop this kind of approach on a larger scale, encompassing socio-economic criteria and user interests early on in the planning procedure.

***The ambitions and difficulties of the French 1992 Water Act***

By and large, the legislative principles governing water management in France date back to the French revolution in large part, as shown by two key points : i) water and rivers are common heritage, the modification of which is subject to administrative authorisation, and ii) distinction is made between dominial waterways (major, navigable rivers managed by the state) and non dominial waterways (managed by riverside communities) (Zamuth, 1991). Water management by drainage basins was introduced by the 1964 Water Act, whereas the Water Act of 1976, the 1984 Pisciculture Act and the 1987 Civil Security Act provide for integrated resource management, including environmental conservation measures. However, these institutional reforms have proven to be insufficient, serving primarily to conciliate uses while conservation only became an issue when environmental degradation was a problem for user satisfaction. The need for a more ambitious reform became clear, encompassing regulatory reform, increased enforcement measures, and most important defining new institutions and procedures for comprehensive management of aquatic resources (Dupont, 1991 ; Zamuth, 1991).

The 1992 Water Act has formally introduced the idea of comprehensive management of water as a resource and environmental heritage. Legislators have clearly stated the desire to conciliate the conservation and restoration of aquatic ecosystems with the satisfaction of all forms of use of water and aquatic environments. Water management must henceforth strive to establish lasting equilibrium between conservation measures and user satisfaction, and must include stakeholders in participatory planning of resource management at the local level.

New planning procedures were defined at two levels : on the scale of major drainage basins, managed in France by six Water Agencies (*Agences de l'Eau*), and on the scale of local drainage units (1000 to 2000 $km^2$). Each Water Agency must develop a 'water management and development master plan' or *S.D.A.G.E.* (*Schéma Directeur d'Aménagement et de Gestion des eaux*), defining orientations and development programmes for their respective territories. A comprehensive diagnosis and assessment programme serves as the basis for developing the *S.D.A.G.E.*, making it possible to define strategies and general measures to improve overall management of resources, and to better co-ordinate local actions. Established with the state and local officials, the orientations set forth in the *S.D.A.G.E.S.* are a reference for all administrative decisions regarding dominial or non dominial waterways, thereby reinforcing existing regulatory and enforcement measures. However, the *S.D.A.G.E.* policies aim to provide for 'soft' management, relying heavily on incentive measures and support to local management operations to achieve their goals.

Based on the above mentioned experience of local management contracts, a new institutional framework was devised to enable participatory water management at the local level. Local management perimeters are delineated on the basis of physical drainage limits, as well as institutional and socio-economic coherency, in order to set up 'local water management and development programmes' or *S.A.G.E.* (*Schémas d'Aménagement et de Gestion des Eaux*). The *S.A.G.E* are run by a 'local water commission' or *C.L.E.* (*Commission Locale de l'Eau*) comprised of representatives of local stakeholders (50 %) as well as water managers (25 %) and state officials (25 %).

The principle behind the *S.A.G.E.* procedure is that of a interactive system between uses and the environment, where any action modifying any one of the components of the system modifies the entire system. It is therefore necessary to conciliate all uses between each other, as well as with the conservation of natural equilibrium. Moreover, the societal dimension is recognised as essential. In setting up a *S.A.G.E.,* it is highly recommended that the various interests and motivations of stakeholders be studied in depth, and that the value given to specific environments or uses be taken into account. This information must then serve to analyse and define both decision making procedures and the relationships between different stakeholders, expressed in terms of conflict and convergence. By linking data on the environment and resource use to data concerning stakeholder opinions, it should be possible to clarify present situations, and to evaluate the consequences of various strategies with regards to different components of the system through scenario development.

The new French Water Act has thus established what could be termed as environmentally integrated water management. The first examples of *S.A.G.E* procedures have shown that in practice, this approach to planning is rather difficult. The balance of roles between traditional management partners has changed. Stakeholders and users demand direct representation, refusing to be represented through local elected officials, whereas these latter find there legitimacy contested. The increased importance of environment has undermined the authority of the engineering corps, whose knowledge of environmental problems is often too limited. In countries like France where there is little tradition of participatory decision making, it is not surprising that the shift to environmentally integrated management brings up such problems. Nonetheless, the last twenty years or so have seen the slow emergence of bottom-up decision making procedures. Although *S.A.G.E.* development has been slowed in part by socio-political factors, it has also become evident that there is a need to develop and to test new planning procedures that would improve participation and negotiation in such bottom-up management programmes.

In this context, various authors have propose innovative procedures based on prospection or game theory (Mermet, 1992), (Piveteau, 1995). Our work may been seen as a part of this larger reflection, in which we explore the potential of a territorial approach, based on the spatial representation of environmental processes and the use of environments, as well as the values of stakeholders.

## Framework for a territorial approach to water management

### *A necessary debate on environmental values*

Within the *S.A.G.E.* or any assimilated participatory procedure, stakeholders must concert with each other and make choices that will have consequences on both resource use and on the ecosystem. The dangers and limits of organising management on the grounds of ecological constraints were exposed above. It seems impossible to establish direct comparisons between mans activities and nature, as this leads to mixing fundamentally different criteria that have no direct logical ties between them. Indeed, ecological constraints do not exist. Rather, only environmental constraints exist, as identified by man in order to guarantee the survival of an ecosystem he values. Whatever their implications may be, environmental constraints are based on values and as such, they encompass elements, dynamics related to natural process, and values that are strictly human. In this sense, ecology (material elements that may objectively perceived and understood) serves as a cover for values (ideals, subjective perception). In consequence, hierarchical classification of priorities can not be purely scientific. This does not imply that science is supplanted, or that management can do without. It simply means that the place of scientists must be (re)defined, because in management, the scientist no longer practices science, but rather becomes an expert and should act accordingly in following with definition given by F. EWALD (1992) : "*The role of experts would be, rather than to provide solutions and imperatives, to give the understanding that would make the infinite negotiation of the values institutionalised by the theme and experience of environment possible*." The help of science is irreplaceable in attempting to understand processes - the fluvial hydrosystem concept is essential in this regard -, but building a participatory management procedure also depends on understanding and conciliating environmental values that may be concurring or converging, but more likely interlaced. To sort out the complex question of values, the humanities and social sciences must also be called upon : "*The search for a participatory or co-operative approach to planning becomes by necessity environmental, and opens the door to conciliating values that were often conflicting at the start.*" (Berdoulay V., 1995).
The goal of implementing participatory water management brings up the same question, and calls for the development of methods that may contribute to attaining this goal. In developing

an operational procedure for participatory planning in comprehensive water management, two question appear to be essential. The first is to determine how to go about identifying, analysing, and interpreting values that will be the basis for future decisions, and the second lies in identifying the information necessary to planning, how it is to be represented, and what the place or role of information is within the planning procedure. It would seem that identifying and understanding values is a prerequisite to defining information management strategies.

***The ambivalence of environmental values***

A possible key to understanding what makes up environmental values may be found by leading individuals or groups to define their relationships with environments. According to A.Berque, (1990) an environment may be seen as a relationship, that of a group to its surroundings, which interlocks both material facts and representations. Representations are built upon uses of the environment, and inversely, the uses of the environment are determined by the group's representations of the environment. These two dimensions, one symbolic and phenomenal, the other ecological and material, combine with each other in a third dimension, time, to form a *trajection.* Berque does not directly refer to value in his theory, but this notion underlies his work, and is implicit to what he calls *mediance,* the sense of the environment, encompassing objective, cognitive and significance. Mediance is produced via a trajection. Using these terms, the aim of our research is to demonstrate trajection in order to help a group of stakeholders define their mediance. It is by building an information system that we will attempt to attain this goal.

Environmental values are *medial* by definition. Values are made from feelings and emotions, and are a judgement placed upon the material of the environment. Biodiversity, drinking water availability and quality, landscape diversity, flood protection..., these goals are dictated by environmental values, as expressed by different groups. However, these values are interlaced in a complex manner : a part of a floodplain may be considered as having great ecological value. This value will converge with another value considering the same part of the floodplain as being a floodable area for flood dissipation purposes. Its value as a source of gravel is completely divergent, whereas seeing it as a pleasant landscape is ambiguous : it converges with the first two as it is opposed to development works or gravel extraction, but diverges in the sense that its attractiveness might excessively increase passage. Each of these values is tied to the material object : a floodplain subject to innundations that mobilise sediment and determine floodplain mosaics. Sorting out the variety of values projected on a given space is the first step towards concertation. Values can be classified by crossing two criteria : positive and negative values on one hand, and linked to active or passive use on the other. The combination of the two criteria expresses *medial qualities* (resources, constraints, pleasures and risks) which are in fact 'views' or 'clichés' *(prises)* (Berque, 1995), that is to say a metaphorical snapshot combining both physical realities (the floodplain) and phenominal responses (response to risk, to pleasance, to a resource...).

The relationship between stakeholders and the environment generally only concerns specific components of the environment. Members of society do not actually manage or use rivers and forests, but rather properties of these environments : river discharge, or fauna in forests for example (G. Barouh, 1987). As such, stakeholders do not directly perceive ecosystem processes, though these latter may analysed objectively even if they are not fully understood. They only see the ecosystem through the resources it provides, the valuable part that translates in termes of aptitudes or constraints to their uses. This constraint is linked with inadequate resource functioning in certain parts of the user's territory, either because of reasons inherent to the resource itself, or because of impacts related to the use of fossil fuels or direct competition with other uses. Although the stakeholder is often aware of constraints to his needs, he is not necessarily aware of the constraints his proper use causes to other users of the same resource. The aim of a territorial approach is to make mediance easier among a group of stakeholders by visualising the limits of resources and explicating the constraints of each user. The main goal is thus not to explain environmental processes, though this is important, but is to clarify the values of different stakeholders for a given common resource and its different uses, and to locate them is space within the territories of each participant.

***A model for reference***

In the *S.A.G.E.* procedure, upon which we are basing our approach, the relationships between uses and environments must be explained and related to user values that are associated with different uses and environments or components of environments. An inventory of management stakes must be made within a system that includes all information pertinent for each stakeholder, all of the functional processes characterising these resource units, and the values attributed to resource components or functional processes. In a very schematic view, these interactions between use and environmental components can be represented as an effect/response system. Uses produce effects on biotic and abiotic ecosystem components which in turn generate a certain number of reposes that affect the initial use itself or other uses. By modifying the natural system, uses may retroactively affect constrain (impede, limit, degrade...) or favour another use. The symmetry of such a system is only apparent.

The effects of uses on ecosystems and the reposes of ecosystems to these uses are not comparable. It is possible to provide highly objective information on ecosystem processes, accounting for usage impacts on the ecosystem and response phenomena of ecosystems to soliciting actions. However, there are limits to scientific understanding of ecosystem processes. Complex phenomena such as the dynamics of riparian environments or bedload transit remain to be fully explained. It is nonetheless possible to interpret available data as objectively as possible to produce synthetic but realistic representations of ecosystems processes for specific planning needs.

In contrast, changes in the system of uses due to a change in the natural environment can not be ascertained in same manner. When dealing with stakeholder representations, values and interests, the functional relationships that exist between uses can not be made fully objective. Moreover, competition between uses may arise for economic, political or moral reasons that have little if any relation to their effects on the natural system.

It is thus extremely important to distinguish between factual information pertaining to ecosystem processes, and user representations or values attributed to various resources and their uses. Initially, spatial representation of the values of different stakeholders makes it possible to point out potentially conflicting or converging interests, while clarifying the stakes and hand in each case. On these grounds, and by informing stakeholders of the objective functional aspects of the environment concerned and the stakes of individual users, it may be possible to collectively define solutions. The schema in figure 2 is a systemic representation of the participatory management procedure we propose.

Stakeholders may thus find themselves in relation to each other via common resources. In *S.A.G.E.* or similar environmentally integrated water management procedures, distinction should also be made between *Natural environments* as resources and *Water* itself. *Landscapes* may also be included as collective resources linked to subjective and sentimental representations, (J. Viard, 1993). Landscapes are a particular and complex form of environmental resource, the specific characteristics of which will not be developed here, but we should point out that the recognised exceptional quality of certain landscapes may render other uses impossible, whereas landscape management is rarely dominated by a single stakeholder, but rather is generally treated as the object of collective patrimonial and societal values (T. Joliveau, 1994). Space is not considered as a resource in this approach, even though cost may be associated to space and uses may compete for a given space. Rather, geographic location is seen as the framework or index of reference in relating the organisation of environments and uses to each other. In water management, spatial interdependencies and connectivity (upstream-downstream, drainage network - drainage basin, etc.) are very important in understanding natural processes and responses to anthropogenic actions. Location also influences upon mans' activities and management zoning, and is essential ingredient in shifting from sectorial analysis of individual uses to comprehensive planning. Moreover, territories as perceived by each stakeholder may be described by locating and delineating their use of resources.

Whether they are organised or not, stakeholders are groups as identified by a common pattern of specific usage of natural environments and/or resources of the management territory considered. It is the specific nature of use that individualises stakeholders. Uses are defined as a specific form of taking or exploiting a given type of resource. Categories of general activities (power plants, drinking water, fishing, water sports,...) may in fact present very different manners of exploiting resources for a same purpose, depending on the practices of individual users. For example, white water sports have recently become quite popular on the upper Allier river in France. Several stages may be identified in the process of practising white water sports (automobile access to the river, input, navigation, picnicking, camping, takeout, etc.). Moreover, the term 'white water sports' encompasses contrasting forms and motivations (tourist rental, nature sports, competition), that apply to different users. In each case, different types of watercraft may be used (kayaks, canoes, or rafts) and the way resources are used in different stages varies (repeating technical figures in a single rapids, solo trips, large or small groups, presence of spectators,...). All these different ways of using resources have specific impacts, and inversely, different environments present varying aptitudes to these different forms of use : access, riverbed morphology, water and landscape quality, discharge, civil engineering obstacles, etc.

The natural environment may thus be considered as a form of activity perceived by man, that would include aspects such as “ wildlife ” in general or various “ uses ” of fauna and flora. The use of “salmon” may for example include sub-categories such trophic activity, migration, reproduction. Environmental activist groups are naturally stakeholders that value and defend these uses, in synergy with or in opposition to other uses of the same resources (fishermen, hunters, ...).

### *Orientations for a territorial approach*

The first step is to collectively agree upon a common framework for planning assessment, derived from a complete inquiry of stakeholders, including :

- perceived stakeholders, that is to say any user that is perceived by a given stakeholder (with whom uses may be complementary or in competition),
- all the different uses of recognised territories (resource units) of these stakeholders, including both water and environmental resources,
- the perceived aptitudes of these environments and resources for these uses,
- the perceived impacts of each use on environments and water resources.

Each stakeholder is led to describe the properties of different resources in terms of aptitude for their specific usage, as well as the negative aspects or constraints they recognise in relation to other competing or complementary uses. This makes it possible to identify all the aptitudes and impacts as they are seen by stakeholders, and to establish a list of existing or possible conflicts, in sharing water resources, natural environments, and landscapes.

The job of inventorying stakeholders, uses, aptitudes, impacts, conflicts and converging interests is distributed among stakeholders as a whole. Each group must define their own perceptions, while presumably following guidelines that help to make their description clear. In negotiation, stakeholders present their positions and may react to the perceptions of usage aptitudes and impacts formulated by other stakeholders. The long and difficult debate that is to follow, to be conducted with the input of scientists and managers acting as mediators, should lead each stakeholder to improve their awareness of the constraints, stakes and goals of others. This preliminary schema makes it possible to identify major problems and general objectives, while leaving less important issues aside.

The second step involves building an information system in order to describe and to locate territories, environments, resources, landscapes, uses, modifications... This information system must serve as corps data for both spatial modelling of environmental processes and for assessing stakeholder resources and uses. It is important to settle upon a reasonable level of complexity, compatible with available means (software, accessible data, etc.) as well as with the general objectives agreed upon in the first step. This compromise depends on levels of perception, which determine data resolution and the time interval used in modelling. It is of course preferable to locate current uses as best as possible and to effectively evaluate usage intensity and the present state of resources so as to verify stakeholder representations of aptitudes and potential.

The third step is to negotiate objectives in planning and define future actions. This involves agreeing upon a plan of actions, laying out specifications, regulations, operational procedures and of course financial measures, all of which may or may not be territorial, that is to say location specific. At this point, the information system serves as a support for stakeholders in evaluating the stakes and values they each attribute to resources and uses. These representations are subjective, giving varying weight to different considerations, but are not totally dissociated with objective reality and location, as their evaluations are built upon the objective data in the information system. The advantage of this stakeholder evaluation model is that makes it possible to define and locate the stakes of different users, which may then be more clearly expressed to partners in negotiation.

By locating aptitudes and constraints as seen by each stakeholder, this evaluation model makes it possible to show resource potential for various uses, to simulate the impacts of new or changing uses, to respond to questions concerning the conservation or restoration of particular areas. Furthermore, it may serve in delineating areas where certain uses should be reduced or modified, or in building and testing planning scenarios. Unlike technocratic environmental management approaches, the goal is not to produce semi-objective evaluations of anthropogenic pressure and environmental potential. The aim is to lead stakeholders to account for all uses and environmental processes in collective decision making. These models are tools for negotiation rather than for objective assessment.

## Data management strategies

Setting up planning and management programmes requires building a specific information system, and that should take the opinions of concerned parties into account. The information system is in fact based upon a system of interpretation (J. Tarlet, 1985), interpretation being crucial stage, as it though interpretation that planning documents and scenarios are produced. In traditional management, preliminary diagnosis, often technocratic in nature, is then interpreted on the basis of rules defined *a priori*. In contrast, it seems preferable to define interpretation systems in a continuous manner as planning evolves. In a situation where various stakeholders participate in planning, decisions are progressively negotiated on the basis of information. J. Montgolfier and J.-M. Natali (1987) have remarked that choices in acquiring information itself are often subject to meat-negotiation, that may sometimes be more difficult than negotiations in planning. Hence the idea of building the information system with stakeholder participation. It would seem that this participatory strategy would insure us that all the necessary information regard each stakeholder will indeed be included. By involving stakeholders in the choice of information, this policy should either make negotiation of solutions possible, or else point out the need for further data. The information system would thus alternate negotiations and information gathering in a series of cycles during which decision would be made progressively.

This sort of planning procedure obviously requires powerful spatial data processing tools. Recent progress in environmental planning is in part due to increased availability and performance of Geographic Information Systems (G.I.S.) software. When using G.I.S. for territorial assessment, there are a great number of technical choices that affect both the precision and the clarity of results. The means available to participatory management programmes may not authorise sophisticated assessment methods, but in many cases they may not call for them either. Although information is essential to the approach, there are costly pitfalls in putting too much importance on precision. These considerations merit considerable thought when developing a management information system, which implies having sufficient overall understanding of the available options and their implications. We have chosen to review and illustrate essential G.I.S. assessment methods that offer pragmatic solutions to the needs of participatory planning programmes.

***Describing management objects***

Comprehensive water management requires describing a wide variety of resources or environments that may be represented as punctual, linear, surface or even three dimensional objects. These include both natural systems, (drainage networks, aquifers, watersheds, soils vegetal communities,...) and anthropogenic factors (civil engineering river works, roads, landuse, etc ). The spatial relationships between these various objects are complex. Limits are often uncertain and may vary in time (exchanges between floodplain aquifers and rivers, , the importance of ecotones). G.I.S. software make it possible to link location to descriptive information, to store spatial data in appropriate formats, and to adapt data formats to representation and processing needs. Of course not all G.I.S. software are of equal power, but most of the currently available software do provide tools for using the two most common data structure formats : vector data and raster data.

The vector data structure, sometimes referred to as object structure, divides space into objects whose limits and properties are clearly individualised in the information system. Vector data layers or covers are then an assembly of objects that have spatial relationships to each other (common limits, proximity, etc.), whereas each vertor object in a layer is linked to an attribute data base containing descriptive information, often based on typologies. This form of data structure is thus particularly well adapted to delineating recognised objects such as property lines or drainage networks, which may then be described in various ways (discharge, flow direction flow rate, stream order, etc.). Thematically different layers covering the same geographical area may related or intersected via location, even if the covers were acquired at contrasting scales. Depending on resolution, a river could be shown as a line, or as a polygon whose borders could be the river bank, or a limit between the river and a riverside parcel, etc. In the case of the above mentioned river, a polygon representing a 200 metre segment may be bordered by ‘stable’ banks, with riparian forest between 10 and 20 m wide comprised mostly of young willow trees that separate the river from a field where corn was grown in 1995.

Raster data structure is based on regular subdivision of space into rectangular grid cells. This format treats spatial data as continuous phenomena (terrain models, population densities, climatic or hydrological variables,...) whereas the importance of objects is secondary. Raster data structure may serve to interpolate data from points of measure (e.g. for climatic factors), is a powerful tool for spatial analysis (mapping geographic parameter variation, evolution in time, relationships between independent spatial data sets, etc.), and is especially useful spatial modelling. It is of course possible to convert raster data into vector data or inversely, that is for example to convert raster slope data into a vector map of landforms based on classes of slope and exposition (i.e. slope orientation). Although the basic operations in manipulating data sets are actually quite simple, the nature of data sets and the phenomena they describe can make combining data sets rather delicate, and one can see that building an information system for comprehensive water management is a long and complex task.

One of the problems in describing objects is that of choosing adequate scales. In many cases, information system managers choose the highest degree of geographical precision in case it may be useful. However, detailed data sets take up more memory, are more difficult to update, etc. Moreover, data resolution should not only be considered on the level of a given data cover, but rather in light of the possible resolution of the other data sets with which it is to be used. When crossing and combining data sets, it is the lowest degree of input precision that determines output precision, and while it is easy to generalise precise data, increasing the precision of data covers is very delicate. On pragmatic grounds, it is thus more sensible to identify an optimal resolution for sets of data covers based on available data sources and goals in data processing. Moreover, when communicating results to partners in a participatory management programme, synthetic, clear maps are often preferable to less legible, detailed maps. The information system must therefore be able to provide different levels of information destined to different publics and uses. Anamorphisis is for example an interesting way to simplify and group synthetic data describing linear objects (rivers). In figure n°3, the goal is to show river sensitivity to white water sports on the Allier river. At this scale, the study area is essentially linear. In terms of communication and legibility, displaying synthetic classifications in anamorphic columns makes it easier to display several indicators that may be more easily compared.

### *Describing processes*

Once environments and territories have been delineated and described, the way they function, evolve, or react must also be demonstrated as objectively as possible, keeping in mind that these representations must be understandable to non specialists. Systemic models showing interactive relationships between the system components are used to demonstrate which changes in a given component may affect others. Within certain limits, simulation models make it possible to interpret process evolution in time and space. In hydrology and hydrogeology, for example, models now make it possible to calculate discharge from rainfall in catchments, simulate the propagation of pollution or floods, etc.

However, in spite of enormous progress in modelling tools and methods during recent years, there are still many obstacles to reliable spatial modelling of environmental phenomena. The fact the environmental processes are generally interdependent makes realistic modelling of certain phenomena very difficult to achieve, whereas insufficient data covering large areas and long enough time periods is also a frequent problem (P. Coquillard *et al.*, 1995). Coupling models to G.I.S. also gives rise to various difficulties, such as the inadequacy of raster based data for modelling certain phenomena, difficulties in interfacing G.I.S. and model data, or the slowness of model calculations in high resolution real time applications (Abdednego *et al.* 1990). In summary, realistic G.I.S. modelling is still a relatively experimental enterprise, in

which extensive calibration and verification are required to produce models which only reply to specific questions. Linking complementary models, for example a hydrological model and an ecological model, remains a very delicate task.
For these reasons, planning is often based on more approximate functional classifications, based for example on generally recognised laws or simplified models, that present the advantages of being easier to develop and readily applicable to most areas. To give an example, Laurent *et al.* (1995) propose maps of river and aquifer vulnerability to pollution, by applying the Darcy law using a raster based cost-distance function to calculate propagation time. The authors point out their results do not replace hydrodynamic or hydrodispersion models, but provide a working solution for areas where the latter models are not applicable due to lack of data. Although these maps are not the product of simulation, they provide an interpretation of hydrodynamic processes that is useful in planning, provided that planners are aware of the limited precision of the documents in question.
In many cases, environmental processes are represented through indirect evaluation, that is via best-estimate suppositions rather than actually certainties. This sort of representation may be based on extrapolation from observation sites, or on the transfer of outside knowledge. To provide a functional classification of high altitude wetlands in a regional natural park, Etlicher and Bessenay (1996) developed a snow accumulation model based on arial photograph observation of persistent snow patches, linking the presence of snowdrifts to geomorphic variables (altitude, orientation, distance to the nearest ridge,...). In the aforementioned Sioule-Allier confluence environmental assessment (Barge, 1995) bird populations were extrapolated to the study area based on real observations in a neighbouring area (number of spottings per species for each type of environment). The environment classification used in the ornithological study (vegetal communities) was applied to the confluence area, making it possible to provide a reasonably reliable document for ecosystem conservation at low cost (figure n° 4).
The functional characteristics of environments or territories may also be accounted for by delineating and classifying objects based on logical combinations of parameters that describe a group of factors recognised as being determinant in the processes of interest. For example, access to a river may be characterised by combining data covers pertaining to slope, landuse, paths, and roads, producing a synthetic indicator of accessibility on foot, based on the principle that visitors will generally opt for easy access solutions (figure n° 5). The dynamics of riparian environmental rejuvenation due to channel migrations may be demonstrated by relating lateral channel displacement to a classification of riparian environmental units. Figure n° 6 locates different ecological stages of riparian vegetal communities in the Allier-Sioule confluence floodplain. For the same area, diachronic channel mapping was used to calculate lateral migration distance between four observation periods. The maximum rate of migration was retained and mapped as five classes of lateral channel instability (figure n° 7).
On the scale of major drainage basins, a global approach to river ecosystems proposed by Bethemont, *et al.*, (1993), using similar principles to establish a functional classification of river ecosystems. The approach is based on the idea that classification should reflect causes rather than consequences, and that classification must be hierarchical, as causes in fluvial ecology come into play at a variety of scales. In summary, aquatic communities respond to various bio-physical local habitat conditions, which are in turn determined by other natural factors such as river and drainage network morphology, discharge variations, or bio-physical characteristics of their watersheds. This natural framework is also affected by anthhropigenic factors (landuse, water use, pollution, civil engineering works...). Spatial characterisation of these various factors at appropriate scales may then serve to define functionally coherent geographical units for the analysis and management of river ecosystems.

Maps processes and set to scale with G.I.S. are interpreted to delineate fluvial ecosystems, that is units which show comparatively homogenous or characteristic composition for multiple criteria related to ecosystems functions (geology, aquifers, slopes, altitudes, rainfall, temperatures, hydrological variables, climactic vegetation,...) (Wasson, 1996). River morphology and drainage organisation are also characterised and hierarchically classified (types of segments identified according to valley and channel forms, stream order and drainage density) independently to fluvial ecoregion delineation (Bethemont *et al.* in press). The result is a framework of multiple delineations (hierarchical watershed limits, hierarchical ecoregions, and hierarchical segmentation of drainage networks) comprised of units that present characteristic process controls. Anthropogenic actions assessed with data from institutional data banks for different sectors of activity or use (demography and domestic uses, landuse and agriculture, industrial uses and waste, tourism and landscapes, etc..) may be linked to the above mentioned delineations to evaluate impacts.
This framework is destined to serve in spatial analysis and statistical interpretation of punctual data relative to river environments obtained from specialised data banks and fieldwork, (hydraulics, riparian vegetation, water quality, aqautic fauna and flora, impacts of civil engineering works...). Preliminary results show fairly strong correlation between various factors, demonstrating the interest of the approach. The delineation of ecoregions compares well with both seasonal discharge variations and spatial distribution of morphological types of rivers. On the level of individual regions, different types of river segments show characteristic distributions of morphodynamic channel variables (% of length per type of morphodynamic unit, sediment size, etc.) (Andriamahefa, 1995). Moreover, the characteristics fish populations differ from region to region, particularly with regards to the longitudinal distribution of species, this latter showing a strong relationship to upstream-downstream distribution of geomorphic valley types and channel morphology (Wasson, 1996). Further analysis on the scale of ecoregions should lead to isolating bivariate relationships linking natural control factors to habitat conditions and biotic responses. In its present state of progress, this global approach to river ecosystems has also proven to be a valuable planning tool, contributing to the development of the Loire-Brittany *S.D.A.G.E.*, whereas the same approach is currently being applied to the Rhône basin in the *GIP Hydrosystèmes : Zone Atelier Bassin du Rhône* inter-ministry research programme (Rogers and Wasson, 1997).

In describing processes for environmentally integrated resource management programmes there are a range of strategies, varying in their degree of formal representation and understanding from quantitative simulation to expert assessments. In participatory management programmes, depending on the means and objectives at hand, these various strategies will most likely be used conjointly in dealing with different problems, the most important point being that stakeholders grasp and/or accept the results which are produced.

### *Evaluation*

Eastman (J. R. Eastman *et al.*, 1993; J. R. Eastman, 1995), defines evaluation as a process by which decision making rules are applied to a combination of criteria in order to answer to a specific need. In choosing amongst a range of possible solutions, priorities must be defined. Evaluation thus implies combining factors that either encourage or limit the perspectives of given possibilities, leading either to a choice or a hierarchy of options. A wide variety of methods may be used to make evaluations, derived in large part from operational research, to a point where evaluation has become a field in itself (J. Simos, 1990). Most evaluation methods, and in particular those used with G.I.S. first weight individual criteria in relation to measured or supposed importance, and then combine the weighted parameter values. There are various ways to weight parameters, the most current of which was proposed by T.L. Saaty

(1977). Examples of weighted evaluations in environmental management can be found in A. Ottitsch (1996) and B. Etlicher and C. Bessenay (1996). Figure n° 8 shows a weighted evaluation of environmental stress caused by white water sports on the upper Allier river. As no existing scientific approach was able to quantify the stress due to these activities given the data available, (estimated frequencies per type of watercraft, location of rental centres, put-ins, and take-outs, etc.) these parameters were summarised as qualitative indicators and weighted to provide a rough spatial representation of environmental stress.
Evaluation methods may be used to actually make decisions, for example to delineate protected areas based on environmental and landuse criteria. They may also serve to approximate processes or delineate functional reference units as would be the case in making expert evaluations of sensitivity or potential for example, in other words to provide assessment of phenomena for which models are not available by weighting and combining factors in a logical manner. Figure n° 3 gives an example of this type, where a simplified weighting of criteria is based on studies relating observed or deduced impacts on fish populations to the degree of bed sediment disturbance caused by different types of water craft when passing through characteristically shallow reaches. By measuring the proportion of distance per kilometre for each sensitive type of reach, and weighting the degree of sensitivity for each type, (i.e. : flats and shallows coefficient 1; riffles coefficient 2) it was possible to produce a map of sensitivity adequate for decision making. In the aforementioned global approach to river ecosystems (Bethemont *et al.*, 1993), one of the main objectives is to evaluate anthropogenic impacts on river environments. Within the context of a given ecoregion, in itself an indirect functional evaluation, the study of relatively undisturbed river environments would serve to define a state of reference to which functionally similar but disturbed river environments could be compared. It would thus be possible to evaluate the degree of disturbance for river environments with a given region, and by studying the anthopogenic phenomena that are spatially related to the various disturbed environments, the probable causes of disturbance could also be evaluated.

## Discussion

The approach proposed in this article may seem complex. However, the problems brought up by the *S.A.G.E.* procedure of the French 1992 Water Act are not simple either, if one takes their objectives seriously. The framework we have suggested here must be reconsidered in light of progress in other many other fields, particularly those that focus on the problems of negotiation and communication. As it would not have been possible to discuss all of the aspects involved, nor to give adequate coverage to international cases in a single article, we chose to focus on perspectives for applying a territorial approach to participatory planning within the French *S.A.G.E* procedure, and considerations in managing information within this context. This case in France is rather characteristic of international trends, as recent literature shows that water managers are granting increased consideration to socially co-operative planning (Crance and Draper, 1996 ; Harwell *et al.*, 1996 ; Shrubsole and Scherer, 1996) whereas considerable impetus has been gained in research on participatory environmental planning in general (Cocks and Ive, 1996 ; Richards and Wrigley, 1996 ).

One could object that the proposed approach is just as arbitrary as the more traditional ecology oriented approaches we criticised, notably regarding the choice of factors in representing ecosystem processes and in weighting evaluations. It may also seem regrettable that the main argument for such simplified representations is not inherent to the questions studied, but rather to pragmatic considerations of cost and availability. The material components of environments present properties than may be interpreted in order to determine there aptitude to various uses or sensitivity to various impacts. A given soil may be described as well adapted to a specific crop, or particularly sensitive to runoff erosion, but may also be described by the various properties of each of its horizons (thickness, texture, chemistry, permeability, etc.). The choice and description of properties may be more or less complex, but is in fact a compromise between cost, which is partly tied to data availability, and planning needs. Although this may seem a bit shocking to some specialists, it is in fact perfectly reasonable in proposing an expert evaluation. Of course the degree of simplification must be made clear, but may also be improved upon if this appears to be necessary.

Whatever the degree of precision required, the utility of G.I.S. based planning tools in such a procedure is evident. However, we have attempted to shift the centre of interest from the power an precision that G.I.S. enables in 'objective' assessment to the versatility it offers in bringing experts, stakeholders, elected officials, and managers to demonstrate and compare their points of view. Again, in participatory planning, precision is not so important, whereas clarity and adaptability in representing evaluations and mapping opinions may be very important in avoid excessive meta-negotiations about information itself. As pointed out by Kondolf (1995), typologies can be very effective in optimising management procedures, provided that the typologies in question have been sufficiently validated, but this does not mean typologies can replace field verification, which includes consulting local populations.

One of the questions we voluntarily avoided is that of the scales of problems and stakeholder perceptions. In principle, the approach may be applied at any scale of territorial management, but it is obvious that the scale of planning does imply adapting choices in identifying stakeholders and representing information. The problem of scale can be summarised by opposing two positions. One choice is to build participatory planning representations from the bottom-up, or as E. Roe (1996) puts it, from the inside-out. Starting from the smallest perceived resource units and the most locally concerned stakeholders has the advantage of faithfully transcribing to the information system a full understanding of local stakeholders that actually 'manage' these environments on a day to day basis. By hierarchically classifying objects and opinions, it would be possible to interlace local representations and enlarge the working area. However, though it may be possible to account for individual perceptions in local planning issues, individual values are in large part determined by personal experiences and subjective representations that would greatly increase the complexity of the approach. We advocate that it would be excessively difficult to develop a comprehensive system of representations over a large area by generalising local values. Applying the approach to designated groups of stakeholders at appropriate scales appears to be a more workable solution.

One aspect of the problem is that recognised territories do not always coincide with problems, and in particular, impacts due to uses may have effects well beyond the limits of stakeholder perceived territories. In France, a hydraulic development programme that included building several major dams in the Loire basin opposed the interest of residents in the upper basin to those living in the lower part of the basin. Their respective territories of reference dc not coincide, but are interdependent in terms of hydrology and ecology, leading to conflict between diverting local interests. During the debate that followed, in spite of 'objective' management arguments for the dams, activist movements and large public opposition made it necessary for the State to intervene, abandoning part of the programme. Other examples are not lacking, particularly examples of conflict over international waterways.

One of the strengths of fluvial ecoregion approach is that it provides a hierarchical framework that clearly demonstrates global and regional basin processes to stakeholders who do not feel they actually share resources with inhabitants of neighbouring regions. By dividing the basin

into regions that integrate both ecological and socio-economic criteria, it is possible to identify regional stakes and problems in planning (Bethemont and Wasson, 1996) and it may thus be possible to link local representations to regional and global considerations. It thus follows that perhaps a more effective solution for participatory planning lies in adapting scale and procedures of stakeholder representation to problems. This would imply establishing a hierarchy of planning zones and stakeholder groups, and adapting strategies for representing stakeholder values at different resolutions.
This also brings up the problem of coherent zoning. In a hierarchical zoning for water management, boundaries could be defined on the basis of both hydrological and socio-political limits as in the *S.A.G.E.* procedure. However coherent that may seem, it still presents the potential problem of favouring place central stakeholder interests and disadvantaging stakeholder interests near limits. It would seem that the solution lies in defining institutional procedures that adapt to multiple zonings or that enable planners to overcome the problem of limits (Feitelson, 1996). In short the problems of scales and boundaries in stakeholder representation in certainly one of the more difficult aspects to be dealt with in developing a territorial approach to participatory planning.

As it stands now, only a few *S.A.G.E.* programmes are actually under way in France, most of which are still in their preliminary stages. The problems of integrating stakeholder values into planning procedures are far from solved, and the coming years should bring up more interesting problems.

## References


Abednego B., Caloz R. and Collet C. (1990), L'utilisation des SIG dans la modélisation en hydrologie de surface, *Geographica Helvetica,* **4**, pp. 161-167.

Andriamahefa H., (1995) *Régionalisation de la morphologie des cours d'eau dans le bassin de la Loire : approche par le faciès d'écoulement* - Cemangref BEA/LHQ et Université Jean Monnet Saint-Etienne, Rapport de DEA de Géographie : pp. 63

Barge, O. (1994), *Essai méthodologique d'évaluation environnementale d'un linéaire par cartographie informatique, application au problème du développement des loisirs d'eau vive en Haut-Allier*, Section de Géographie, Université Jean-Monnet, Saint-Etienne, Mémoire de Maîtrise de Géographie, pp. 129.

Barge O. (1995), *Information géographique et patrimoine naturel, échelle régionale, échelle locale*, Section de Géographie, Université Jean Monnet, Saint-Etienne, Mémoire de DEA Interface Homme/Nature, pp. 76
.
Barouh G. (1987), La décision au fil de l'eau, systèmes de pensée et d'action à l'oeuvre dans la gestion des milieux naturels en France, UER des Sciences des Organisations, Université Paris - Dauphine, Paris, Thèse de Doctorat, pp. 583

Barraqué B. (1995), *Les politiques de l'eau en Europe*, Paris, La Découverte, pp. 301

Berdoulay, V. (1995) Les valeurs géographiques, *Encyclopédie de la géographie*, Paris, Economica, pp. 383-400

Berque, A. (1990) *Médiance, de milieux en paysages*, Montpellier, GIP reclus, 1990 pp.163

Bethemont, J. (1992) Les grands bassins fluviaux et le concept environnemental*, Revue de Géographie de Lyon*, 67,(4), pp. 257-260

Bethemont J., Degorce J.-N., Dupuis B., Joliveau T. and Wasson J.-G. (1993), *Approche écosystémique du bassin de la Loire : éléments pour l'élaboration des orientations fondamentales de gestion*, Saint-Etienne, CRENAM-CEMAGREF, pp. 102+150

Bethemont J., and Wasson, J-G. (1996) L'homme et la Loire, La Houille Blanche, (6/7) pp. 32-40.

Bethemont, J., Andriamahefa, H., Rogers, C., and Wasson, J-G., (accepted) La typologique régional de la morphologie des cours d'eau : application au bassin de la Loire et perspectives rhodaniennes. *Revue de Géographie de Lyon*, **72** :

Boddaert, A. (1990) *La Loire déchirée*, Editions de la Nouvelle République, 1990 pp. 144

Cocks, D. and Ive, J. (1996) Mediation support for forest land allocation: the SIRO-MED system, *Environmental Management*, **20**, (1) pp. 41-52.

Coquillard P., Hill D. and Gueugnot J. (1995), Simulation d'écosystèmes et S.I.G. : une interactivité nécessaire, Journées de Réflexion sur "Paysages, concepts et outils", Saint-Etienne, 18 janvier 1995, Réseau PNR SIG Centre-est, Fédération des Parcs régionaux, Atelier Technique des Espaces Naturels, C.R.E.N.A.M., pp. 39-46

Crance, C. and Drapper, D. (1996) Socially cooperative choices : an approach to achieving resource sustainability in the coastal zone, *Environmental Management*, **20**, (2) pp. 175-184.

Dupont, Ph. (1991) La gestion intégrée des milieux aquatiques : une démarche nécessaire et incontournable, *La Houille Blanche* (7/8), pp. 591-594.

Duport, L. (1991) De l'aménagement itégrée à la gestion globale des rivières : les contrats de rivière ont 10 ans, *La Houille Blanche* (7/8), pp. 549-553.

Eastman J. R. (1995) *IDRISI, un SIG en mode image*, Lausanne, Centre Régional IDRISI Francophone, E.P.F.L., pp. 645

Eastman J. R., Kyem P. A. K. and Toledano J. (1993), A procedure for multi-objective decision making in GIS under conditions of conflicting objectives, EGIS'93, Gênes, pp. 438-448.

Etlicher B. and Bessenay C., 1996, Le S.I.G. des Hautes-Chaumes foréziennes : pour une gestion écologique de l'espace, *Revue de Géographie de Lyon,* **71** (2), pp.111-120.

Ewald, F. (1992) L'expertise, une illusion nécessaire, *La terre outragée, les experts sont formels*, Editions Autrement, Paris, pp. 204-209

Feitelson, E., (1996) Some spatial aspects of environmental impact statements in Israel. *Geoforum*, **27**, (4) pp. 527-537.

Frissell, C. A., Liss, W. J., Warren, C. E., Hurley, M. D., (1986) A hierarchical framework for stream habitat classification: viewing streams in a watershed context, *Environmental Management*, **10**, (2) pp.199-214.

Harwell, M. A., Long, J. F., Bartuska, A. M., Gentile, J. H., Harwell, C. C., Myers, V., Ogden, J. C. (1996) Ecosystem management to achieve ecological sustainability : the case of South Florida, *Environmental Management*, **20**, (4) pp.497-521.

Joliveau T. (1994), La gestion paysagère de l'espace rural : questions, concepts, méthodes et outils, *Revue de Géographie de Lyon,* **69** (4), pp. 325-334.

Kondolf, G. M., (1995) Geomorphological stream channel classification in aqautic habitat restoration : uses and limitations, *Aquatic conservation: Marine et Freshwater ecosystems*, **5**, pp. 127-141.

Laurent F., Graillot D. and Dechomet R. (1995) Rivers and Groundwater Vulnerability to Accidental Pollutions. Spatial Analysis of Vulnerability Areas, The International Emergency Management and Engineering Conference, Nice, France,, May 9-12, , n.p.

Long, G. (1985) Phyto-écologie et amnéagement rural, In: *Fondements rationnels de l'aménagement d'un territorie*, M. Lamotte (Ed.) Masson pp. 57-94.

Malaval, P. (1991) Une action trop souvent négliée : l'entretien des cours d'eau, naturels ou aménagés, *La Houille Blanche* (7/8) pp. 555-558.

Marchand, P. (1992) Gestion Socialiste et problèmes environnementaux, *Revue de Géographie de Lyon*, **67**,(4) pp 309-318.

Mermet L. (1992) *Stratégies pour la gestion de l'environnement*, Paris, L'harmattan, pp. 205

Naiman, R.J., Lonzarich, D. G., Beechie, T. J., and Ralph S. C., (1992) General Principales of classification and the assessment of conservation potential in rivers, In: Boon, P. J., Calow, P. and Petts, G. E., (Eds.) *River Conservation and Management*, John Wiley, Chichester, pp. 93-124.

Ottitsch A. (1996) The role of G.I.S. technology in an environmental planning process, experiences from the project "Land Use Potential Analysis Achenkirch", *Revue de Géographie de Lyon,* **71** (2), pp. 147-154.

Piveteau V. (1995) *Prospective et territoire : apport d'une réflexion sur le jeu*, Antony, Cemagref, pp. 298

Pols, M., and Verne B., (1987) *L'entretien des cours d'eau en Rhône-Alpes : Bilan, diagnostic, et pistes de travail*, Memoire de fin d'études, ISARA Lyon - DRAF Rhône Alpes, pp. 97, 9 annexes.

Richards, K. and Wrigley, N. (1996) Geography in the United Kingdom 1992-1996, *The Geographical Journal*, **162**, (1), pp.41-62.

Roe, E. (1996) Why ecosystem management can't work without social science: an example from the California northern spotted owl controversy, *Environmental Management*, **20**, (5) pp. 667-678.

Rogers, C. and Wasson J-G, (1997) Les Hydro-écorégions du bassin rhodanien français. Rapport Univ. St-Etienne CRENAM / CNRS U.M.R. 5600 - Cemagref Lyon BEA/LHQ - GIP Hydrosystems : Zone Atelier Bassin du Rhône : pp. 97

Roqueplo, P. (1992) L'expertise scientifique, consensus ou conflit, *La terre outragée, les experts sont formels*, Editions Autrement, Paris, pp. 157-169.

Saaty T. L. (1977), A Scaling Method for Priorities in Hierachical Structures, *J.Math.Psychology,* 15, pp. 234-281.

Shrubsole, D., and Scherer, J., (1996) Floodplain Regulation and the Perceptions of the Real Estéate Sector in Brantford and Cambridge, Ontario, Canada. *Geoforum*, **27**, (4), pp. 509-525.

Simos J. (1990), *Evaluer l'impact sur l'environnement*, Lausanne, Presses polytechniques et universitaires romandes, pp. 261

Sormail, L. (1991) La demande sociale d'aménagement des cours d'eau. Recencement des principaux objectifs Priorités, *La Houille Blanche* (7/8), pp. 529-532.

Steinitz C. (1993), Un modèle de raisonnement pour la planification paysagère, *Cahiers de l'IAURIF,* **106**, pp. 38-46.

Tarlet J. (1985) *La planification écologique*, Paris, Economica, pp. 140

Viard J. (1993) Le conflit social, gardien du paysage, *Pages Paysages,* (4), pp. 32-37.

Wasson, J-G. (1989) Eléments pour une typologie fonctionnelle des eaux courantes : 1. reuve critique des quelques approches existantes, *Bull. Ecol.,* **20**, (2), pp. 109-127.

Wasson, J.G. (1992) La rivière et l'homme : vers une gestion par bassin intégrant la dimension écologique, *Revue de Géographie de Lyon*, **67**,(4), pp. 333-343

Wasson, J-G. (1996) Structures régionales du bassin de la Loire, *La Houille Blanche,* (6/7), pp. 25-31.

Zamuth, M-E. (1991) Nécessité, genèse et vie d'une réglementation des actions sur les cours d'eau, *La Houille Blanche* (7/8), pp. 543-547.

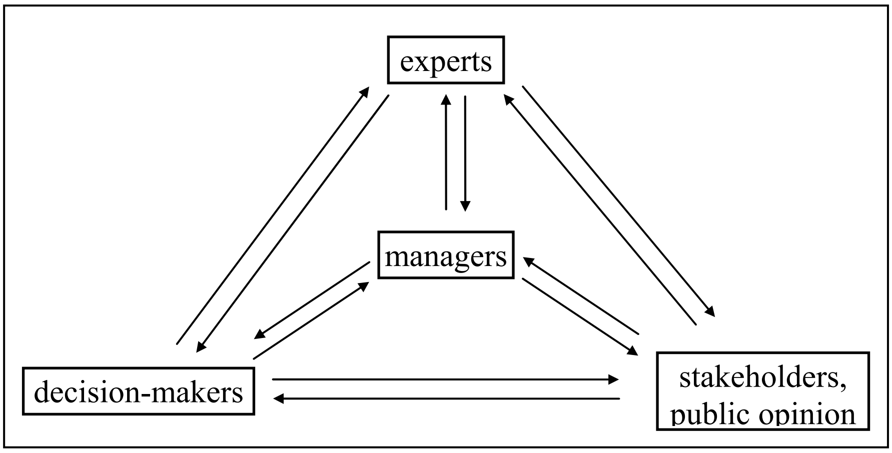


Figure 1: Particpants in integrated management, and the role of information exchange (from LONG, 1985 ; modified).

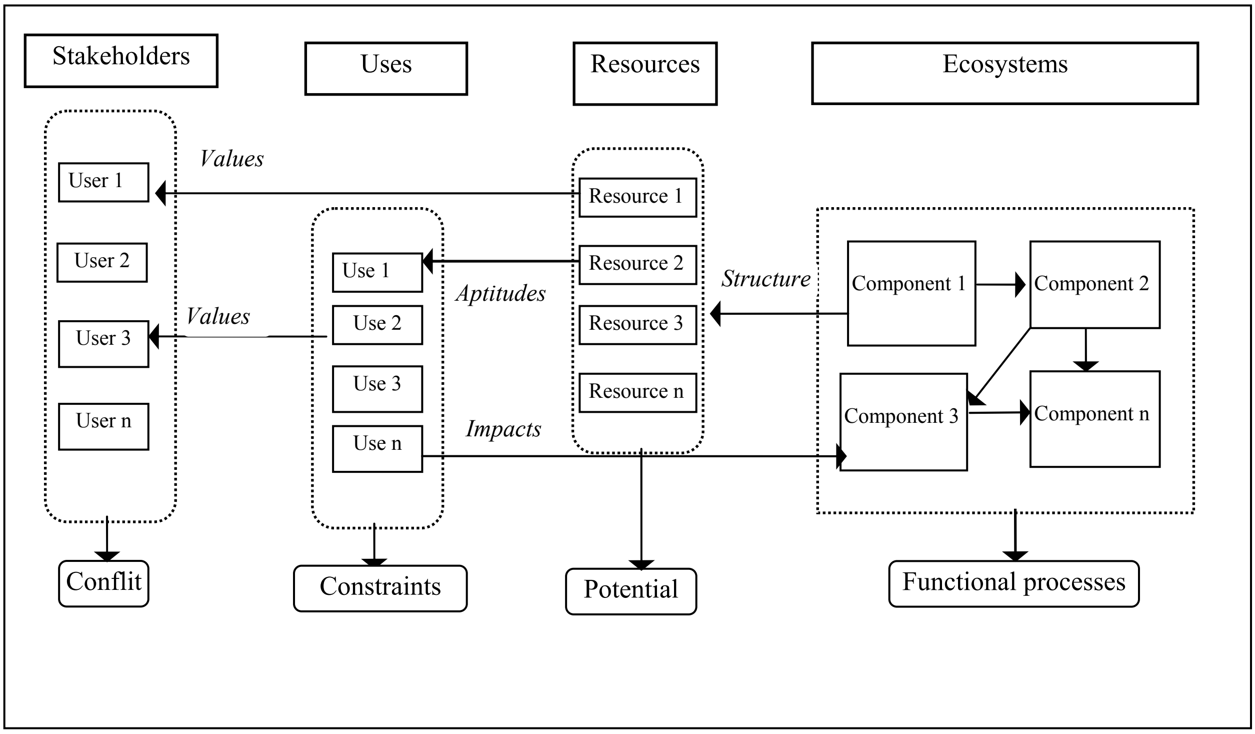


Figure 2 : Proposed schema of Stakeholder/Ecosystems interactions.

Figure 3 : Sensitivity to riverbed disturbance On the Upper Allier river (France).

Figure 4 :Ornithologic evalutation at the Sioule Allier confluence (France).

Figure 5 : Pedestrian access to waterways at the Sioule Allier confluence (France).

Figure 6 : Development stages of riparian vegetation at the Sioule Allier confluence (France).

Figure 7 : Lateral channel instability of the Allier river near the Sioule Allier Confluence (France).

Figure 8 : Ecological stress evaulation due to whit water sprots on the upper Allier river (France).