GESTA
Revista Eletrônica de Gestão e Tecnologias Ambientais

SOCIAL PARTICIPATION IN THE ENVIRONMENTAL FLOW ASSESSMENT: THE SÃO FRANCISCO RIVER CASE STUDY

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Abstract
Traditionally, water resource management has been developed using an essentially technical approach. Currently, public opinion on water resource management is formed as a result of growing environmental concerns and social conflicts arising from poorly planned actions. Environmental problems are complex and have multiple dimensions, including social and economic. Therefore, the inclusion of a human dimension in integrated assessment methodologies is required for the introduction of new elements to the water management planning process. Environmental water allocation (EWA) is understood as the quantity, quality and distribution of water required for the maintenance of the functions and processes of aquatic ecosystems on which people depend. Within the various holistic assessment methodologies, the Building Block Methodology (BBM) was found to be the most suitable, in the Brazilian context, for maintaining and restoring essential elements of the natural flow regime. This article describes the process of social participation in the environmental flow assessment (EFA) for the Sao Francisco River, and compares it with some of the lessons learned from EFA in other parts of the world. The process involved multiple stakeholders who have conflicting interests. BBM was used to guide the field interviews, to incorporate the empirical observations by the local population and to guide the methodological procedures of the multidisciplinary team. The results of the study indicate the effectiveness of this holistic approach in organizing the elements to be evaluated. It also facilitated important contributions to the establishment of a dialogue between the actors to achieve a better understanding of the multiple aspects involved in the decisions associated with the EWA.

Key words: social participation, environmental flow assessment, building block methodology.

INTRODUCTION

The water crisis is a controversial subject, and divisions exist between those who accept the existence of a global water crisis and those who do not (Castro 2007). By studying different ways of thinking about the "environmental crisis", Acselrad (2010) analysed the environmentalist view in terms of two models: utilitarian and cultural. According to the former model, the environment is seen as a unique entity composed of material physical resources, with no specific and differentiated socio-cultural meanings. In this view, the environment is expressed by quantities of resources. On the other side, the cultural model contemplates the purpose of uses and considers the environment endowed with multiple socio-cultural qualities. Such sociocultural qualities can be linked to the ecological functions - referring variously to the habitat, biological, or systems properties or processes of ecosystems – that directly or indirectly provide benefits to human populations, known as ecosystem goods (e.g. food) and services (e.g. waste assimilation) (Costanza et al. 1987, Daily 1997).

These two models – the utilitarian and cultural - help in understanding the different approaches to establishing an environmental flow regime. In the utilitarian model, social-cultural diversity is disregarded. The main imperative advanced by this model is the obligation to intervene on behalf of the environment. However, the cultural model was chosen to guide our study. We understand that natural resources are utilized by people, whose interests and social structure influence the significance and perception of the environment, varying according to personal values and identity, their social positions, religious beliefs and activities. As a consequence, any change in the state of natural resources, such as modifications of a river flow regime, affect river users unequally, due to the different value given by them to the resource and due to the different capacity to adapt or recover from such a change. Anthropogenic interventions on diverse ecosystems, both terrestrial and aquatic, cause losses of ecological properties, which, in turn, cause environmental damage that differently affects biodiversity and humans (Daly and Farley 2003). The main causes of impacts on rivers are the abstraction of water, the fragmentation of lotic bodies by dams, the removal of riparian vegetation, and the modification of the physicochemical water properties, all resulting in biodiversity change through the elimination of important species and disturbance to the balance of ecological communities.

Such modifications of the natural river flow not only reduce the amount of water available in the rivers, but impact the maintenance of ecological functions of freshwater systems, thus compromising their capacity to provide a full range of goods and services (Das Gupta 2008), increasing competition for resources and potentially leading to disputes and conflicts. Such ecological services are endowed with socio-economic values that are difficult to evaluate and are potential sources of conflict due to their oscillation between abundance and shortage.

Funtowicz and Ravetz (1994) classified the study of this type of problem as complex. Environmental systems, according to them, are complex, since they involve deep uncertainties and a plurality of legitimate perspectives that cannot be captured by a deterministic, linear causal analysis.

The fields that encompass complex studies include ecology and the social and human sciences. These authors consider that a complex problem of this sort cannot be studied from one single and segmented perspective without losing sight of essential aspects of the problems analysed. The authors recognize two levels of complexity: (i) the ordinary, characteristic of biophysical systems, where there is an absence of self-consciousness and complex purposes; and (ii) the emergent or reflexive, characteristic of social systems, technical or mixed, involving humans.

Both complexities – ordinary or reflexive – depend on diversity for their own sustainability. However, in ordinary complexity, these diversities follow natural patterns of dynamic equilibrium that confer stability in the face of disturbances through the interactions of various elements and subsystems. These dynamics unfold in the different spaces and levels of aggregation within which the ecosystem organizes itself. They cannot be explained from a mechanistic or functionalist viewpoint. As a result of actions by human beings, these systems have characteristics such as “individuality in addition with some degree of intentionality, consciousness, perspective, symbolic representations and morality” (Funtowicz and de Marchi 2000).

The concept of environmental flow assessment aims at understanding what are the flow requirements of river to maintain their ecological integrity and continue to provide goods and services to society (Das Gupta 2008). A healthy environment, provides ecosystem functions (ecological processes that provide life and production), which are enjoyed by man in the form of services coming from this environmental homeostasis (MEA 2005).

For this reason the establishment of an environmental flow regime requires not only the study of the ecological functioning of the river system, but also the participation of all social groups affected in the process of defining scenarios, with equal opportunities for deliberation.

In the São Francisco River Basin (SFRB), social conflicts triggered by the use of water are frequent. The scenario defined by conflicts over water allocation is characterized by disputes involving power generation, agriculture, fisheries, tourism, navigation and conservation of aquatic ecosystems, among others, in which the establishment of a program for water allocation depends on the processes of negotiation between the conflicting social actors. If the natural resource is socialized, any discussion of its allocation is necessarily situated within the scope of the social order.

This article describes the participation of extractive users (artisanal fishermen and small farmers) of the SFRB in the environmental flow assessment process. These groups have a rich knowledge base that incorporates natural cycles, fishing and rice planting. The researchers who study this process have scientific knowledge about the complex behaviour of river ecosystems. Both groups seek a similar goal: to determine the quantity, quality and distribution of water required for the maintenance of the components, functions and processes of the aquatic ecosystem on which people depend.

METHODOLOGY FOR ENVIRONMENTAL FLOW ASSESSMENT

The environmental flow assessment requires social decisions about ecosystem services and about the desire for their preservation. This goal may be expressed in terms of the river flow regime that should be maintained.

Many different methods have been developed to assess environmental flow for different rivers in the world (King et al., 2000). Some of these methods involve sophisticated modelling and data processing and are based on the consideration of successive variations in flow. Some are based on defining and maintaining the hydraulic habitat preferences of particular target species of importance. Others are driven by the opinions of outside researchers, environmentalists and managers. Others still are simply based on the experiment of releasing water through the dam gates and subsequently assessing the effects of the release. Holistic methods rely on a consensus view of the flows necessary to maintain or restore the desired conditions for all the processes and components of the river (biodiversity, water quality, sediment transport and channel morphology, social, cultural and economic aspects). These approaches use a representation of the hydrological regime that is established by the analysis of many diverse interests, both scientific and socio/cultural. To accomplish this, a multidisciplinary team of specialists from different fields, such as hydrology, hydraulics, geomorphology, biology, sociology and economics is required. The team should reach a consensus about the flows required either to achieve predefined environmental objectives, or to define a series of scenarios, from which an optimal choice can be made (O'Keeffe and Le Quesne 2009).

The Building Block Methodology (BBM) and Downstream Response to Imposed Flow Transformations (DRIFT) appear to represent the most attractive of the various existing holistic methodologies. These methodologies provide frameworks for collection, analysis and data integration expertise to provide an estimate of the effects of flow changes. The BBM can be applied to rivers for which limited data are available, but the team of experts must be experienced and organized to facilitate the interactions in the exchange of knowledge throughout the stages of the process (King and Louw 1998).

The social assessment framework within the BBM aims to provide information about the uses of aquatic resources by the riparian communities. The purpose of collecting this information is to demonstrate the importance of a healthy aquatic ecosystem for maintaining lifestyles from the users' perspective. This process involves riparian communities (and other stakeholders) in the task of reconciling environmental objectives for the river and ensures that the social data collected can also be used by the biophysical researchers conducting the EFA.

CASE STUDY: SÃO FRANCISCO RIVER BASIN

The SFRB occupies 8% of the national territory of Brazil and covers seven of the country's states. The river basin exhibits not only physiographic, social and economic differences but also conflicts arising from the intense competition for water required for various uses throughout the area.

The main channel of the SFRB has a length of 2,696 km. The São Francisco watershed has a drainage area of 634,781 km² and contains 503 municipalities. **Figure 1** presents the political-administrative divisions included in the watershed.

The SFRB is divided into four physiographic regions, defined in terms of altitude: High, Medium, Sub-medium and Low. The main hydro-climatic characteristics of the river basin are summarized in Table 1 for each of these physiographic regions.

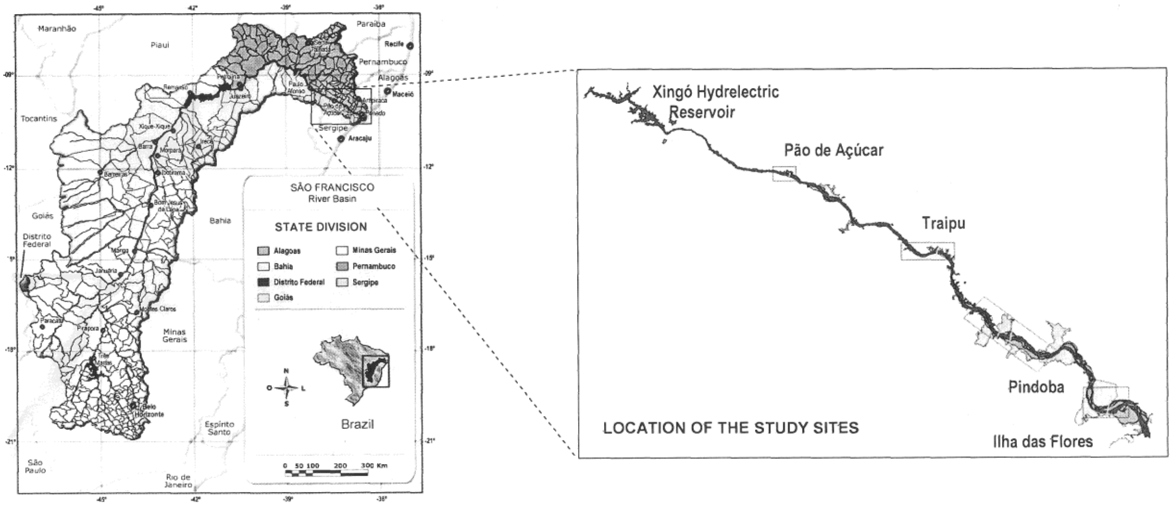

Figure 1 - São Francisco River Basin and the study sites

Table 1 - Main hydroclimatic characteristics of the San Francisco River Basin

Characteristic	Physiographic Regions			
	High	Medium	Sub-medium	Low
Predominant climate	Tropical moist and temperate	Tropical semi-arid and dry sub-humid	Semi-arid and arid	Sub-humid
Mean annual precipitation (mm)	2,000 to1,100	1,400 to 600	800 to 350	350 to 1,500
Average temperature (C)	23	24	27	25
Average annual insolation (h)	2,400	2,600 to 3,300	2,800	2,800
Average annual evapotranspiration (mm)	1,000	1,300	1,550	1,500

Source: ANA / Strategic Action Program – PAE (ANA/ GEF / UNEP / OEA), 2006

The SFRB exhibits sharp socio-economic contrasts. It includes areas of great wealth, densely populated areas and high-poverty areas. It also includes vulnerable and highly dispersed populations. The total population of the river basin in 2000 was 12,796,082 (CBHSF 2004).

Historically, the river basin was occupied for agricultural purposes. Livestock, including cattle, goats and sheep, were raised. The Caatinga and Cerrado biomes in the basin are all impacted by anthropogenic activities. Currently, all types of water uses are represented in the basin. This diversity of use represents a significant challenge and requires an integrated water resources approach to management.

Irrigated agriculture is an important driver of regional development in the basin. Generally, irrigation is used to raise crops with higher economic value and higher water demands, such as grains, fruits, and vegetables. The area of irrigated lands in the basin is 342,712 ha (CBHSF 2004).

The expansion of irrigation has placed pressure on the soil and water and has resulted in significant replacement of vegetation cover. Agricultural development resulting from the expansion of irrigation has also increased the use of agrochemicals (e.g., insecticides, fungicides, herbicides and inorganic fertilizers) all of which will contaminate the soil and water if they are used improperly.

The estimated hydroelectric potential of the SFRB is approximately 25,320 MW (MMA 2006b). Eighteen reservoirs are currently working in the SFRB. Many of these reservoirs have multiple uses. In addition to power generation, the multiple-use reservoirs deliver human and industrial water supplies, serve to adjust flow rates, improve the navigability of the river, provide flood control, and support irrigation, tourism, recreation, and fishing.

The hydroelectric plants in operation in the basin are essential sources of electrical power for the Northeast subsystem. They represent the basis of the region's energy supply. These power plants are essential because the region's energy production potential has reached its limit.

Approximately 96% of the Brazilian electrical power system is interconnected. The system serves all of Brazil's regions. Electrical energy can be produced, preferably in areas offering a greater relative abundance of water, and distributed subject to the limitations of the transmission network. This feature highlights the broad potential for economic benefits offered by the interconnected operation of the Brazilian electrical system. The interconnection of electrical systems in Brazil has allowed the use of diverse hydrological basins between different regions, thanks to the coordinated operation of the reservoirs. However, a consequence of this is that any changes in hydro power generation, as a result of changes in flow management in the river (e.g. following implementation of the environmental flow recommendations) will have implications beyond the basin itself.

The São Francisco River is now navigable with difficulty. The river has historically been navigated without restrictions. Currently, however, some vessels are unable to use the river owing to intense siltation. The land use in the basin has produced increased volumes of sediment. The presence of increasing amounts of sediment causes the river banks to become unstable and causes the formation of new sandbanks.

The São Francisco River supports the largest biomass and the highest diversity of freshwater fish in the Northeast region. More than 150 species of native fish have been identified in the river basin (MMA 2006a). Among the most important fish in the rivers and natural lakes of the basin are the migratory and the sedentary native species. The large number of endemic species found only along the middle course of the river is noteworthy.

The basin has been heavily fished along both its upper and its lower reaches. The basin's fish resources provide food for the local population and attract many fishermen. However, the artisanal fisheries have declined sharply in recent decades as a source of food and as a livelihood for the population of fishermen. The basin's fisheries are in visible decline for several reasons, including the blockages of the river by introduced sediment, the pollution produced by domestic sewage and agricultural activities, and the environmental impacts caused by the operation of dams.

The cascade of dams along the São Francisco River sharply reduces downstream flooding. The dams prevent the flooding of marginal wetlands and consequently prevent the natural production of fish eggs and larvae in these habitats. The marginal wetlands, nurseries for the largest fraction of the aquatic life of the river, have been virtually destroyed. Moreover, the dams hamper the upriver migration of most species.

In addition, the riparian vegetation, which once formed an environment favourable to aquatic communities, has been degraded or has disappeared. The loss of riparian vegetation has contributed to the decline of fish stocks. The decline of these stocks has harmed the economy of the basin and has increased the difficulty of fishing as part of daily subsistence.

ENVIRONMENTAL FLOW ASSESSMENT FOR THE LOWER SÃO FRANCISCO RIVER

The history of the São Francisco River, as exemplified by participants, illustrates the changes that have affected the extractive riparian communities of small farmers and fishermen. Recently, these communities combined fishery production and plant extraction with agriculture. They developed a survival strategy that consisted of adapting to the dynamics of the river flow in combination with various productive activities. Their survival depended on a balanced aquatic ecosystem that can produce the resources required to sustain their lifestyle. In this sense, their living conditions can be seen as an indicator of the health of the aquatic ecosystem. Based on the Building Block Methodology, the social participation of Environmental Flow Assessment for the Lower São Francisco River (downstream of Xingó dam, the most downstream dam in the river, about 50 km from the river mouth), followed a sequence of activities adapted from Pollard (2000) and described below.

1. Identification of potential riparian communities and the selection of study sites

The choice of study sites depended on the location of the gauging discharge stations and on the identification of communities along the river. In addition, study sites were chosen by considering the locations at which samples (water quality, vegetation, and ichthyofauna) could be collected most easily. Four study sites were selected, two located on the right bank, Pão de Açúcar and Traipu, and two on the left, Pindoba and Ilha das Flores (Figure 1).

2. Identification of resource users and key focus groups.

Meetings for this purpose were held with focus groups in the villages Pão de Açúcar, Traipu, Pindoba and Ilha das Flores. The focus groups indicated that the combination of extractive activities with agriculture continues to exist. The artisanal fishery has experienced changes. A major rice-growing crop remains, but it has developed substantially and has changed its family production system. As elder community members relate, "the women planted the rice on the lake. The floods went from November to March, and people fished for their living. The wetlands started to fill up in November and it was high until March, and then came the dry season, and as it dried, people would plant the rice".

3. Prioritization of the relative importance of each resource or use

Fishing was ranked as the most important use relative to other water uses, such as agriculture and recreation. However, it was found that agriculture was also considered as a highly important use in some locations. The importance given to agriculture can be explained by the loss of wetlands and by the resulting loss of opportunities for planting rice.

4. Seasonality of use

This information was obtained through questions about periods of high and low water flow. This information was used to construct tables that provided the description of the linkages among the resources, the purposes the resources were used and the period the its resources were used in relation to the calendar of flood periods.

5. First link with flow: identification of general riverine water levels associated with each resource

For the Pão de Açúcar communities, the greatest loss was represented by the changes in the flood patterns and the decline of the lagoons. The participants stated that floods formerly occurred every year. However, "now the river only fills once in 10 years". In Traipu, similar problems were reported. These problems involved both floodplain agriculture and artisanal fishing. The participants stated that if the water level in the river was one meter higher than now, during the spawning season, it would be enough to improve the fishing opportunities even if the river did not fill the wetlands. The participants also indicated that water quality problems were present in addition to river flow problems. They stated that the river water has becoming very clear and that this change in the water also contributed to the decline in the amount of fish.

6. Second link with flow: the occurrence and seasonality of flow

The primary information from interviews with participants at the four sites indicates that the differences between the flood and drought seasons no longer exist. The local residents used to fish in the wetlands during the flood period and fish in the river during the drought season. The same kinds of fish were available throughout the year, but they were more abundant during the floods.

7. Third link with flow: past and present riverine conditions

An important change reported by the people interviewed in the village of Pão de Açúcar was the intensification of irrigated agriculture for coconut crop and the introduction of cattle. These changes have produced a decrease in the number of jobs in this area. This change began during the 1990s. The subsequent decrease in agricultural activity has been felt intensely. The situation in Traipu is similar to that in Pão de Açúcar. The participants stated that the operation of the hydroelectric Xingó dam, which began during the 1990s, ended the production of rice. As a result local residents then begun to plant grass. The change to this crop decreased the opportunities for agricultural labor. Fishing was the only remaining option.

8. Determination of the desired state of the river

The state of the river desired by the riparian communities depends on the definition of a set of reference ecological conditions. These reference conditions are defined by considering the river in its former pristine state. This state corresponds to ecological conditions that are suitable to maintain the diversity and quantity of the resources considered.

The reference condition identified for the four study sites was the state of the river previous to the operation of the Xingó hydroelectric dam. Formerly, the highest flows occurred during the summer, whereas the lowest flows occurred during the spring. The participants unanimously observed that the flow regime is now reversed: "now the lowest flows occur during the flood season". The interviewers at the four study sites were unanimous on the following goals: a) to increase the number of fish and restore the diversity of native species; b) to obtain a predictable river flow; and c) to fill the wetlands to plant rice in floodplain areas.

There is recognition that, even if the natural flow regime could be reinstated, the reference conditions will not be restored. This is mainly because the sediment regime in the lower river has been irreversibly changed. The upstream dams intercept the great majority of the sediment that formerly washed down the river. In consequence, the natural turbidity of the lower river has changed to largely clearwater conditions, and the sediment-hungry flows have eroded the river banks and shallowed the channel, further dislocating the channel from the floodplains. The most spectacular demonstration of this is the erosion at the river mouth, with the lighthouse which was placed at the mouth in the 1980's now almost one kilometre off-shore.

Short of the removal of the dams, there is little that can be done to reinstate the sediment regime, so that a new set of conditions has to be catered for in the lower river ecosystem. Many of the riverine fish species have been replaced by estuarine or marine species, and these now form the basis of the artisanal fishing. The remaining floodplain wetlands can be reconnected to the river, as well as by restoring higher floods.

9. Environmental Flow Assessment Workshop: gathering and cross-checking of information by the BBM specialist team

The EFA workshop aimed to define the environmental flow regime so that it would fulfil the needs of the modified ecosystem and the riparian communities of the São Francisco River. At this stage, the exchange between the scientific knowledge base and the traditional knowledge base played a crucial role in the research. The information from the riparian communities was combined with the technical knowledge about the behaviour of the aquatic ecosystem and it was the base to recommend environmental flows required for the Lower São Francisco River. Maximum and minimum flows (Figure 2) were recommended for both maintenance conditions: a normal year, when all the relevant functions and processes are working fully, and a dry year, when the flow of the river is sufficient to guarantee the survival of all species of concern and the integrity of the important ecosystem processes. Further negotiations about the consequences of implementation of environmental hydrograms are necessary, involving the São Francisco basin authority and stakeholders, and may lead to its acceptance and implementation.

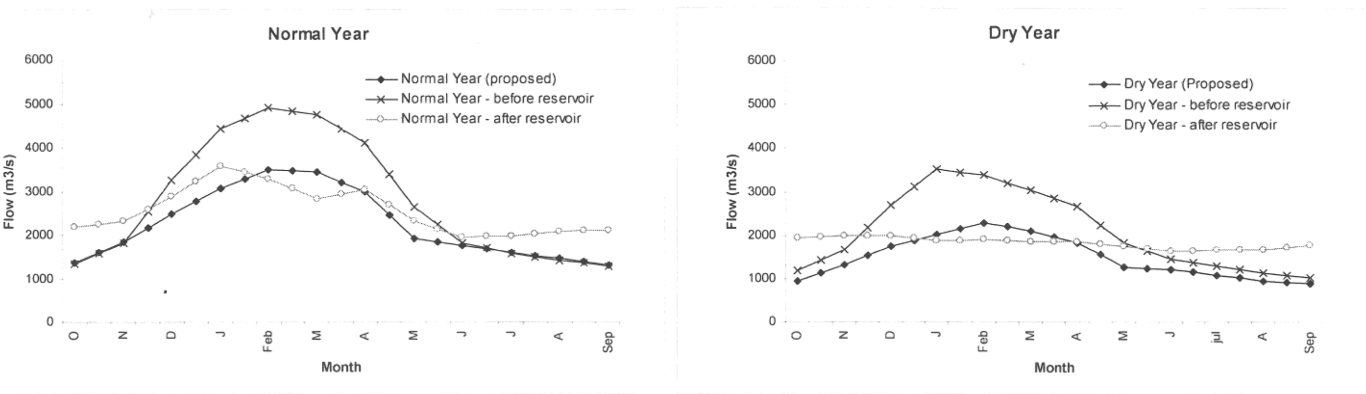

Figure 2 - Environmental flow hydrograms required for :(I) normal year and (II) dry year

DISCUSSION

The adoption of cultural reasoning (Acselrad 2010) in the EFA for the São Francisco River recognizes not only the scientific data but also the perceptions of the extractive communities and the small farmers. This approach produced a very rich experience, both epistemologically and pragmatically.

To accept the complexity of the environmental water allocation issue without treating it in a segmented manner represented a serious challenge for the researchers as they integrated the data obtained from diverse sources. The researchers observed that their knowledge and objectives strongly resembled the knowledge and objectives of the riparian extractive communities. In certain ways, the information collected from these communities focused attention on a reality that was traditionally apprehended from one single and segmented perspective, as indicated by Funtowicz and Ravetz (1994).

The observation of the riparian population and their multiple activities and dependence on the resources created a consistent database. In this sense, the BBM provides a worthwhile structure for the interviews with the key focal groups at the four study sites. This process was used to collect and integrate the information required for EFA.

Eventually, the success of environmental flow assessment and implementation, as with all other water management issues, becomes a societal choice, dependant on political, economic and social factors. Even with the best scientific and monitoring information available, environmental flows will only be implemented where there is a general appreciation and support for the importance of sustaining flows for conservation, where there is the political will to use rivers within sustainable limits, and where there is a recognition of the long-term economic benefits of protecting water resources, rather than the short-term maximization of consumptive uses.

Optimistically, there has been a very widespread understanding and acceptance of the concept of environmental flows worldwide, over the past two decades, at least at the level of policy and legislation. Le Quesne et al (2011) state that they know of no countries which have not, or are not presently, discussing the reform of their water policies to include environmental flows. The problem remains that, despite these excellent intentions, very few countries have made the transition from policy to implementation.

CONCLUSIONS

The social participation in the environmental flow assessment analysed in this study is characteristic of the first step in this process: the contribution of the extractive riparian population (fishermen and small farmers). The choices made by these participants reflected the motivation that links them with the natural resources. There is a need to change the present flow regime, in which the river has been adapted to the requirements of some of the people and their perceived needs. The principle of the environmental flow is to try to get back to the former adaptation of the people to the flow. In this sense, the desire of these participants is to get back to the former way of managing their resources.

In this stage of the work, the application of the BBM to the EFA of the Lower São Francisco River resulted in environmental flow recommendations that reflected the traditional knowledge base of the extractive riparian population and the technical knowledge base of the biophysical domain. Subsequent decisions about the environmental water allocation will depend on a process of negotiation among all the stakeholders, including those who hold political power, society and the water users of the Lower São Francisco River.

The results achieved by the study demonstrate that the adoption of the BBM facilitated the construction of a scenario aimed at less degradation of the environment. In addition, the method served to articulate views and to achieve a consensus about the desired condition of the river. Given the environmental hydrograms proposed at this stage of the BBM, the further scenarios should consider the loss of the riparian population and the aquatic ecosystem and should not rely solely on utilitarian and fragmented reasoning.

ACKNOWLEDGEMENTS

This study was conducted by the ECOVAZÃO research network and was supported by a grant from the Water Resources National Fund (CT-HIDRO) and by the National Research Council (CNPq), Brazil.

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