

## **Integrated water management for the Epitácio Pessoa Reservoir in the semi-arid region of Brazil**

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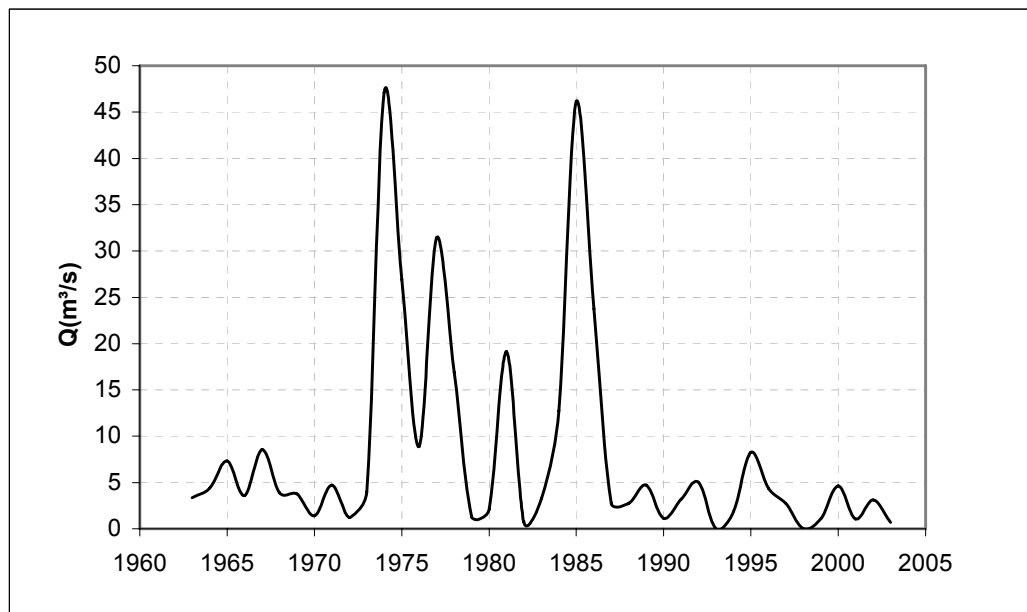
**Abstract** The Epitácio Pessoa Reservoir (538 hm<sup>3</sup>), in the semi-arid region of Brazil, is used for urban water supply, irrigation and fishing activities. In 1998 and 1999, due to a severe drought, irrigation and fishing activities were prohibited and urban supply was strongly restricted, resulting in dramatic social and economic consequences. A methodology has been developed to propose directives and regulations to improve the water management combining a strategic environmental evaluation with an improvement of socioeconomic development of the rural surrounding area. The methodology is based on three main points: (i) socioeconomic diagnosis; (ii) environmental diagnosis; and (iii) Causal Chain Analysis. The latter is initiated by the building of “Causal Matrices”. The main problems are detected and classified with a priority concept. A trend attribute is also given by these problems. Then the causes of each main problem are analysed and clustered into technical, managerial, political and social, and cultural and economic types. A chain between one cultural and economic cause and one or more technical causes, through both other cause types, is drawn on the matrix, so it is easy to propose directives and actions to promote water management looking at integrated socioeconomic sustainable development.

**Key words** causal matrices; chain analysis; Epitácio Pessoa Reservoir

### **INTRODUCTION**

The Epitácio Pessoa Reservoir is located in the Cariri Region in the semi-arid part of the northeast of Brazil. The Cariri Region is the driest of the so-called “Drought polygon”. In this region, all the water supply is assumed by superficial reservoirs because of the inexistence of groundwater. The Epitácio Pessoa Reservoir (535 million cubic meters) was built in 1956 by Departamento Nacional de Obras contra as Secas (DNOCS) with the purpose of supplying Campina Grande City for human and industrial uses, some irrigation around the reservoir, and to promote aquaculture activities in the reservoir.

The reservoir basin, 12 389.14 km<sup>2</sup> of area, is formed by the high part of the Paraíba River basin and by the totality of the Taperoá River basin. The long term average annual rain amount in the basin is 305.4 mm, with a high spatial and temporal variability. The rivers are intermittent, flowing in the rainy season, i.e. from January to



**Fig. 1** Incoming flow at the Epitácio Pessoa Reservoir.

April. In Fig. 1, the incoming flow to the reservoir has been registered since 1969. We can see several drought periods: 1969–1972; 1979; 1982–1983; 1993; 1997–1998. We also note that in all the 1990s the incoming flow to the reservoir was situated below the long term average value. This is due to rain amounts which were also below the long term average value, and to the construction in the basin, in the 1980s and 1990s, of many small reservoirs for water supply in the rural zone and small cities.

In 1997 and 1998, due to a severe drought, irrigation and fishing activities were prohibited, and urban supply was strongly restricted, resulting in dramatic social and economic consequences. At present, the water volume in the reservoir is at its highest level, but all the water uses other than human supply continue forbidden by judicial sentence. This is due to the pressure (lobby) of the water supply company of the Paraíba State, CAGEPA, a state company, which operates the system. However, the water law of 1997 indicates that the water of the reservoir belongs to the federal union, because the dam was built by DNOCS, a federal organization.

This paper presents the methodology that has been used to propose directives and regulations to improve the water management, combining a strategic environmental evaluation with an improvement of socioeconomic development of the rural area. Two corollaries were stated to direct the studies: (i) in a semi-arid area, a reserve with a great volume of water must be the main promoter of the local development; (ii) due to the fragility and the vulnerability of the aquatic ecosystems in a semi-arid area, the socioeconomic development is durable if it preserves the environmental quality.

## METHODOLOGY

The methodology proposed is based on three main points: (i) a socioeconomic diagnosis; (ii) an environmental diagnosis; and (iii) main problems identification with their causes.

### **A socioeconomic diagnosis**

The socioeconomic diagnosis proposes to evaluate the main indicators of the development by observing their spatial aspects. The spatial scale has been determined to be: the surrounding area of the reservoir, the nearby municipality areas and the basin area. This allows comparisons between the areas to detect the influence of the reservoir on the indicators. Primary and secondary data were used and analysed to build some social, economic and cultural indicators. The primary data were collected during observations in the field and meetings in the town halls of Boqueirão and Cabaceiras, in the offices of DNOCS and EMATER (Empresa de Assistência Técnica e Extensão Rural da Paraíba) and in civil associations. A questionnaire was also applied to a significant sample of the rural population. The secondary data have been obtained in official and specialized sources of economic and social data, the “Instituto Brasileiro de Estatística” (IBGE), the “Instituto de Desenvolvimento Municipal do Estado (IDEME), the “Departamento de Informática do Sistema Único de Saúde” (DATASUS), the “Programa das Nações Unidas para o Desenvolvimento” (PNUD), the “Instituto de Pesquisas Econômicas Aplicadas” (IPEA), universities, and other governmental offices. The observed indicators describe the demographic aspects, the quality of life, the productive structure, employment and incomes, health, schooling, the basic cleansing, the infrastructure and the agrarian situation.

### **An environmental diagnosis**

The environmental diagnosis consists of a survey of the environmental conditions of the Epitácio Pessoa Reservoir at present. The study shows the resultant environmental impacts of the current activities developed, and to be potentially developed from the water users of the surrounding area of the reservoir.

The environmental diagnosis was made from the records of water users by the state water agency – AAGISA (2003), records of farms of the region carried out by the DNOCS in 2005, observations *in situ*, studies of maps in scale 1:100 000 of the region, and ecobathymetric data of the reservoir made in 2004.

During the *in situ* observations a questionnaire was applied, at a representative sample base, to get information about the land and water users in the population that live around the Epitácio Pessoa Reservoir.

### **Main problems identification with their causes**

In order to propose directives for a sustainable development of the region based on the water presence, we looked at all the present or potential problems identified in both diagnoses in an integrated approach to assess their main reasons. For practical purposes, the number of main problems identified was limited to five. The main problems are not necessarily independent. One can be the cause of other. The causes of the main problems were depicted from the diagnoses and then clustered into technical; managerial; political and social; and cultural and economic types. For each main

problem, a priority concept was given in ascending order, i.e. priority of order one is for the main problem that needs the most urgent attention. Also a trend attribute was given to the main problems. The trend attributes show the tendency of the problem, supposing there are no modifications of the public policies which can affect the development of the area or the management of the reservoir. For each identified cause, a priority was also attributed to in each group of causes.

## RESULTS

The socioeconomic diagnosis shows that there is no significant difference between the indicators when one considers the three areas of observation. This means that, until today, the presence of the reservoir has been unable to promote some socioeconomic development. The study also shows a very low social, economic and cultural level of all the population of the region. It is clear that the local population does not play its citizen role in the sense that it does not feel responsible for the low socioeconomic level of the area. For example, the negative consequences of droughts are perceived as the “will of God”.

The environmental diagnosis shows that the local population lacks pollution and environmental questioning. Also the population is not aware of environmental problems, and the environmental fiscalization by the public offices is precarious. A disordered land use with a very low riparian vegetation density was also observed. Conflicts of water use by the population are drastic. The basic sanitation infrastructure is deficient.

From both these diagnoses, five main problems were identified, which are summarized in Table 1.

**Table 1** Main problems identified.

Main problem	Priority	Trend
Water use conflicts	1	↑
Low socioeconomic level	2	→
Disordered land occupation	3	↑
Pollution sources	4	↑
Lack of institutional articulation	5	↓

For each of these problems the causes were identified and then clustered into four groups: technical; managerial; political and social; and cultural and economic. During the identification and clusterization process, the authors always had in mind that a chain must exist from the economic and cultural causes going to the technical causes through both the political and social causes, then to the managerial causes. In this way it is possible to design directives and recommendations, which integrate interdisciplinary preoccupations (ANA/GEF/PNUMA/OEA, 2004). In the same way as was done for the main problems, all the causes in one group were ranked in respect to the priority, and a trend was given to each cause. As an example of the result, Fig. 2 presents the causal matrix of the water use conflicts (a problem identified as priority order one). The causal chain can be seen.

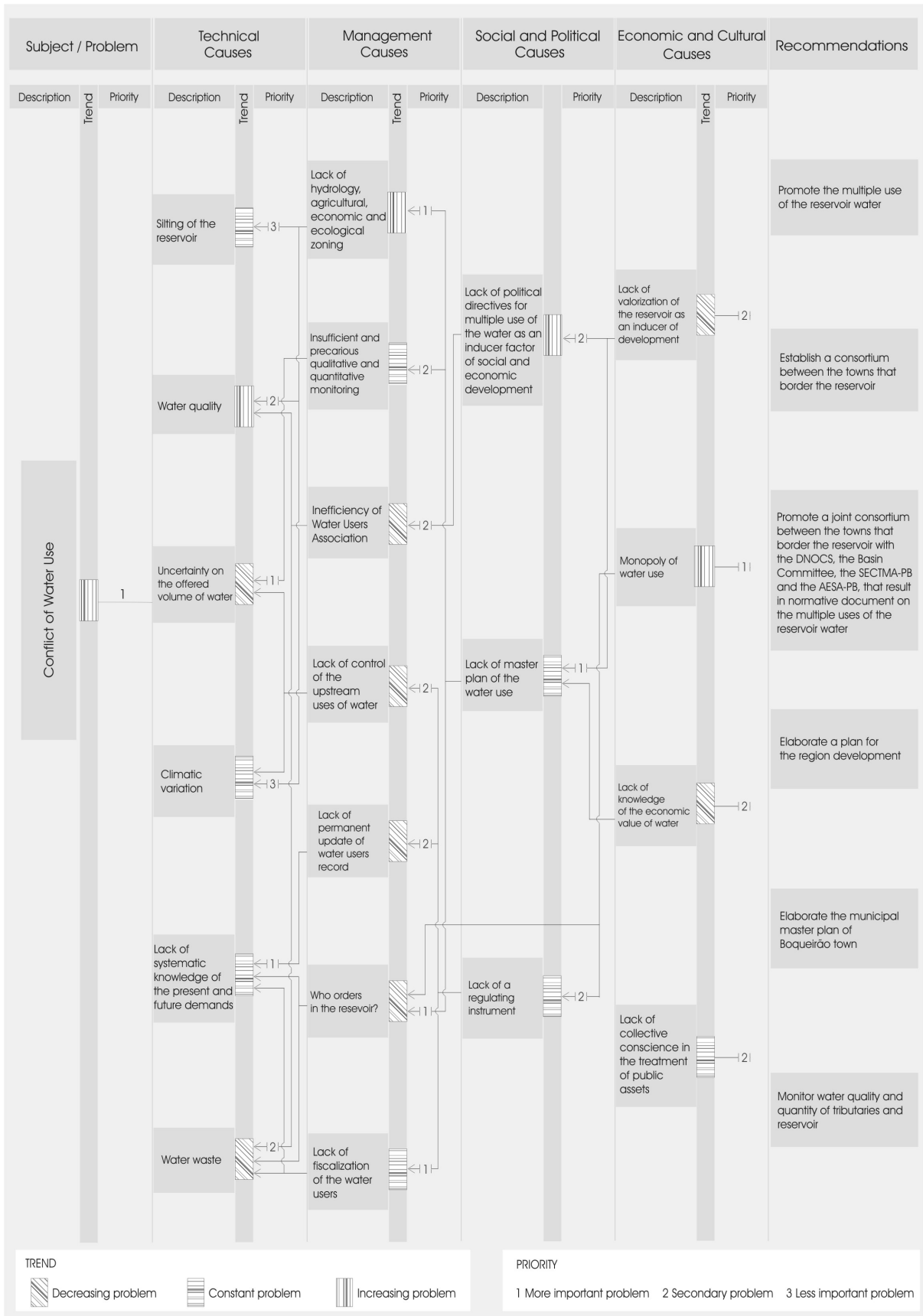


Fig. 2 An example of the Causal Matrix with the Chain Analysis.

## **CONCLUSIONS**

Integrated water management of the Epitácio Pessoa Reservoir is focused by a new methodology, a causal chain analysis of some main problems. Problems and causes were depicted. Causes were clustered in groups, which allow the design of a chain from economic and cultural causes to technical causes. Then, naturally, directives, regulations, programmes and actions, which integrate interdisciplinary components, are easy to build to promote water use with sustainable development of the surrounding area.

**Acknowledgements** The authors thank DNOCS for allowing the financial support of this research.

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