doi:10.1016/j.eiar.2015.07.004

USING CAUSAL MAPS TO SUPPORT EX-POST ASSESSMENT OF SOCIAL IMPACTS OF DAMS

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ABSTRACT

This paper presents the results of an ex-post assessment of two important dams in Brazil. The study follows the principles *of Social Impact Management,* which offer a suitable framework for analyzing the complex social transformations triggered by hydroelectric dams. In the implementation of this approach, participative causal maps were used to identify the ex-post social impacts of the Porto Primavera and Rosana dams on the community of Porto Rico, located along the High Paraná River. We found that in the operation of dams there are intermediate causes of a political nature, stemming from decisions based on values and interests not determined by neutral, exclusively technical reasons; and this insight opens up an area of action for managing the negative impacts of dams.

Keywords: causal maps, participatory methodology, governance, Paraná River, Brazil.

1. Introduction

It is indisputable that large-scale public works (LPW from here on) have sparked an intense debate around their ensuing benefits and damages. On the one hand, they have been considered privileged tools for regional development. For example, the building of large dams has been seen as an opportunity to irrigate new lands and guarantee food supplies for a rapidly growing population. Large dams have also shown their usefulness in controlling river flows, thereby reducing the catastrophic economic and human losses caused by floods. The hydroelectric energy generated has fuelled new industries and cities emerging as a consequence of development. Likewise, building dams has created demand for large workforces (Takeuchi et al., 1998).

On the other hand, in too many cases these achievements have involved an excessive and occasionally intolerable social and environmental cost (CMR, 2000). The failure of numerous megaprojects (Flyvbjerg et al., 2005), the resistance aroused amongst affected populations (Gunvald, 2010), the unequal distribution of costs and profits (Adams, 2000), and the emergence of ecological awareness (Martinez-Alier, 2002) have fuelled opposition to LPW. In brief, social recognition of the socio-environmental impacts of large-scale development schemes has begun to question the absolute legitimacy of such projects (Burdge, 2004a; Taylor et al., 2004).

Science has played an important role in this debate. Research has enabled us to increase the amount of information available on the consequences of LPW and as a result has thrown light on ways of maximizing their positive impacts and diminishing their harmful effects on the environment and on people (Gleick, 2000). Emerging at the beginning of the 1970s in the USA, Impact Assessments are one of the methodological tools that science has developed in the attempt to achieve this delicate balance. As these methodologies have evolved, the need to include both the social context where major schemes are carried out and their effects on local communities has also become evident (Becker, 1997; Becker and Vanclay, 2003; Vanclay and Esteves, 2012). In this way Social Impact Assessment (SIA) methodologies which "include the processes of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions" (Vanclay, 2003: 2) have gradually been developed. Although the specialized literature states that SIA must be undertaken before projects become operational (Becker, 2001: 312; Goldman and Baum, 2000), other scholars understand ex-post assessment as a section of SIA to be carried out during the monitoring phase (Ahmadvand et al., 2009; Western and Lynch, 2000).

In accordance with this second view, this paper presents the results of an ex-post assessment of two important Brazilian dams, using the principles *of Social Impact Management*. As we will see shortly, this approach provides a methodological framework suitable for analyzing the complex changes triggered by hydroelectric dams. In putting this approach into practice we advocate the use of collective causal maps elaborated from local knowledge. The purpose of this paper is to demonstrate the potential offered by participative causal maps for identifying and mitigating the ex-post social impacts of hydroelectric dams. A secondary goal is to provide the social science literature on dams with sound information and data for scoping future SIAs. The case studied is that of the community of Porto Rico (Brazil), located on the banks of the Paraná River, downriver from the Porto Primavera and Rosana dams.

2. Different approaches in SIA

In order to carry out an ex-post assessment in Porto Rico a range of approaches and practices were considered from amongst the existing assessment methodologies in the SIA. The main arguments distinguishing the various approaches revolve around the function and purpose the SIA should fulfill in the LPW project cycle; also what role the LPW-affected population should play in the SIA, and how local knowledge should be integrated into the assessment.

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a) Function and purpose of the SIA

Regarding the function and purpose of SIAs, the distinction made by Vanclay and Esteves between *Social Impact Statement* and *Social Impact Management* (2012: 5) is of special interest. The first is set in motion once the project has been designed, concentrates on the impacts caused by the LPW, and has as its main objective the approval of the latter by the relevant authorities. In the second approach, *Social Impact Management*, SIA is seen as an instrument for strengthening the decision-making process in the design, execution and management of the scheme. This approach endeavors to contribute to LPW risk management in that it aims to reduce the economic, social, and environmental costs sustained by both the companies and institutions behind the LPW and the local populations affected. It stresses that the SIA should be involved from the outset as an element in the project's design and should accompany it as an important part of its management and monitoring. This approach broadens the concept of the scheme beyond the works themselves by studying the project in every phase of its cycle and by seeing it as a social process, not merely a technical exercise (Burdge and Johnson, 2004: 15-20).

Consequently in *Social Impact Management* the contextual, longitudinal, and relational aspects of the socio-environmental effects of LPW take on special importance. Thus within this framework we can study a) impacts during the entire cycle of the project, including its management after construction and its long-term effects (longitudinal) (Lockie, 2009); b) interactions between environmental and social (relational) changes (Van Schooten et al., 2003); and c) local, socio-cultural and institutional contexts where the project is carried out (contextual) (Burdge and Vanclay, 1995).

Below we exemplify the usefulness of these three dimensions (tridimensional analysis from here on) in assessing the socio-environmental impacts of dams. Raising the containing wall leads to the flooding of land upriver and the migration of affected communities, who suffer the breakup of their social networks. Stated in these terms, it would seem that this social impact is an inevitable consequence of the building and operation of the dam. However, other factors may have contributed to causing this impact, such as a company culture in which the design of the eviction/relocation process excludes those affected by it from the decision-making process, or extractivist neo-developmentalist government policies promoting economic growth through exploitation of natural resources (Gudynas, 2009). Taking into account these social, political and cultural aspects involves seeing LPW and their impacts as products of a specific society, thus increasing our ability to understand and alter them. We should then add to this contextual analysis a longitudinal axis which identifies, on the one hand, the effects on host areas of emigration to cities by displaced populations, and on the other, the changes experienced by riverside populations as the course of the river is modified. It should be noted that the Social Impact Statement approach is only used to identify dam impacts concentrated on the flooded area since these are the most visible and direct impacts. The Social Impact Statement is carried out in the first phases of the LPW, often before the completion of the dam's construction and the alteration of the river's course. This means that the impacts produced downriver and the long-term effects as a consequence of management of the hydroelectric plant and reservoir water are downplayed or simply not identified in this approach. Thus these impacts do not become targets for measures

for management, elimination, mitigation, or compensation (Penvenne, 1996). However, local populations living downriver suffer permanent changes due to these effects (Adams, 2000; Égré and Senécal, 2003; Tilt et al., 2009). If this dimension is not included in the SIA there may be impacts stemming from the dam which are not considered as such since they are distant in time or space, thus obstructing the identification of efficient mitigating measures. Lastly, the relational dimension shows that there are constant feedback loops between environmental and social impacts. For example the reduction of sediments, held back by the dam, leads to impacts in soil renewal in the delta and affects agricultural production, in turn affecting the incomes of downriver farming communities (El-Sayed and Van DijKen, 1995). These populations may respond to falls in production by increasing their use of fertilizers and thereby generating new environmental impacts. If this relational dimension is not factored in there is a high probability that the increase in fertilizers will be seen as unrelated to the dam, and thus the causes of this new environmental impact will not be correctly diagnosed.

In *Social Impact Management* the complexity of the changes wrought by LPW are seen to demand a broadening of analytical scope. Tridimensional analysis makes it easier to identify those intermediate causal elements which, due to their contextual, relational, or longitudinal nature, are normally overlooked, but which also take part in the generation and definition of impacts. Improved understanding of these factors is the preliminary step needed to increase the success of any future intervention which seeks to mitigate its negative effects.

b) Local participation in the SIA

Another argument emerging from the debate between *Social Impact Statement* and *Social Impact Management* is around technocratic rationality (Dryzec, 1997), which minimizes or excludes local participation and empowers experts in the LPW decision-making process. This technocratic approach, proper to the *Social Impact Statement,* is premised on secondary, quantitative data (Barbour and Van der Merwe, 2007) and presents itself as the bearer of the objective and neutral principles of neopositivist science. For various reasons this approach is now contested both by local communities and environmental activists, and by critically-oriented social sciences. Firstly, the neopositivist approach does not seem to be the most suitable for addressing the effects of LPW on people (Burdge and Vanclay, 1995; Lockie, 2001). It is logical that those most affected by the building of a dam should be consulted in the assessment of how it will change their lives (Brody, 2000). It should be noted that impacts are not processes of change caused by LPW, but how people feel about, perceive, benefit, or suffer from such processes (Van Schooten et al., 2003: 78). Secondly, the supposed rationality, neutrality, and objectivity of neopositivist science have been called into question from an epistemological standpoint by so-called post-normal science (Funtowicz and Ravetz, 2000). Apart from this, these traditionally ascribed features of science are also extremely debatable when we acknowledge that SIA is carried out in social contexts of conflict where issues of power and inequality are present (Barbour and Van der Merwe, 2007). Thus it should not be forgotten that around LPW and their impact assessment there appears a range of opposing interests which can condition their execution and results. Thirdly, the inclusion of the local population in assessment can grant it greater legitimacy, credibility, and balance (Morris et al., 2011). Fourthly, the inclusion of local

doi:10.1016/j.eiar.2015.07.004

knowledge can afford valuable information on the natural and social environment to arise. This information would otherwise be difficult to obtain or would remain invisible (Becker et al., 2003). Finally, the local community has been considered to play a decisive role at the elaboration of the collaborative causal maps since they are the most affected by the dams impacts all along life cycle project.

3. The case study

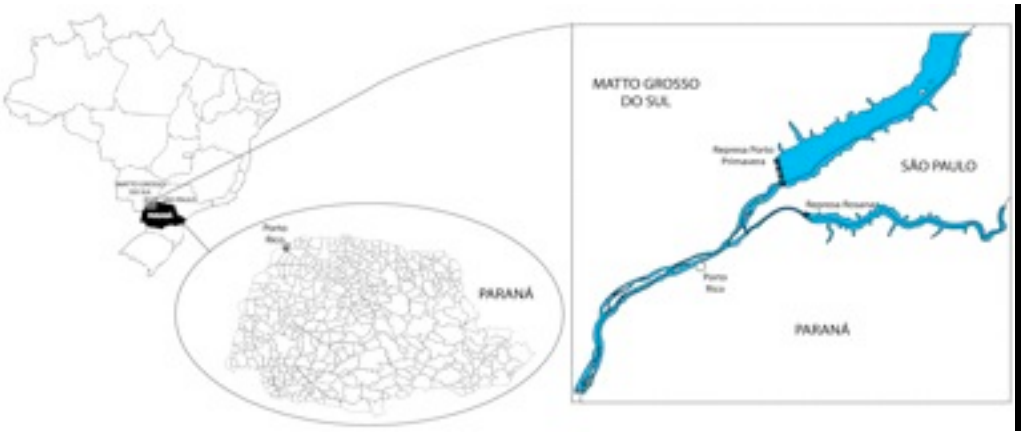
In 2005, a team of geographers from the State University of Londrina (Paraná, Brazil) initiated a study analyzing the hydro geochemistry and environmental impact of the erosion that the construction and operation of the Engenheiro Sérgio Motta hydroelectric dam, known as Porto Primavera, had caused in the High Paraná area around the town of Porto Rico. The team decided that it was essential to include social impacts in order to create a holistic analysis. To this end in 2007 they contacted a group of sociologists from the University of Alicante (Spain) with previous experience in analyzing the socioenvironmental impacts of dams in Latin America. The inclusion of the ex-post assessment of social impacts caused by the dam also addressed a request from the municipal council of Porto Rico, concerned by the effects which environmental changes in the river were having on the town's population.

This population is located at the north-westernmost point of the state of Paraná, very close to the border separating the states of Paraná, Sao Paulo and Mato Grosso do Sul. Porto Rico is a settlement on the left bank of the Paraná River, a few kilometers south of its confluence with its tributary the Paranapanema. On this stretch of the river its flow is directly influenced by the effects of the Porto Primavera and Rosana dams, both situated around 50 km upstream. In 2007 Porto Rico had 2,462 inhabitants. More than 53% of the active population worked in the service sector, highlighting the rapid growth of the tourist industry in recent years, associated with leisure uses of the river (swimming, sport fishing, etc.). Linked to this increasing recreational use of the Paraná various second-home developments had arisen. Apart from this, 44% of the population was employed in agriculture and cattle-rearing. Along with these land-based economic activities, fishing had been a crucial source of income since the founding of the community, carried on either full-time by professional fishermen or part-time as a complement to family diet. However this activity was in steep decline due to shrinkage of catches.

Begun in 1980, the Porto Primavera dam should have been completed in 1988, but a series of setbacks delayed its inauguration until 2000. Thus the building of the dam straddles two distinct political periods. It was begun under the military dictatorship and completed during the privatization of the Brazilian hydroelectric industry under the democratic government of President Fernando Henrique Cardoso. Porto Primavera is a surface dam. As distinct from an overflow dam it needs to contain a huge mass of water to move its heavy generators. The 11 km-long wall holds a reservoir which flooded an area of 2,250 km^2. The hydroelectric plant generates an average of 900 megawatts. The creation of the reservoir involved flooding lands rich in biodiversity and caused significant human emigration –the exact numbers are still subject to debate– triggering socioenvironmental consequences considered to be irreversible (Ribeiro da Silva, 2002).

The Sao Paulo Energy Company (CESP), which built and now manages the dam, developed a plan for the eviction and relocation of the farming community and the last members of the Ofaiê Xavante Indian tribe living on the islands and banks of the river[1] (Hoffman, 2002: 148). Although this process was not free of opposition and setbacks, the lack of environmental legislation compelling developers to undertake an EIA-RIMA made it easier for the company to impose its conditions (Scarpinella, 1999). In the course of our study CESP specialists admitted that the dam's energy production has been particularly inefficient and that so far its economic, social, and environmental costs have exceeded the benefits and profits generated by the hydroelectric plant (Map 1).

Map 1
Map of the Porto Primavera and Rosana dams, Paraná, Brazil



Source: (Canesso, 2009). Drawn up by the authors.

The Rosana dam is located on the Paranapanema River close to its confluence with the Paraná. It was begun in 1980 and became operational in 1987. It has a total capacity of 353 megawatts and is managed by the North American multinational Duke Energy. While the flooded area is not very large (220 km^2), Rosana is only one of a chain of eight dams along the Paranapanema River. Thus the river is strongly anthropized and its flow is completely regulated to serve the needs of hydroelectric energy production.

During field work carried out for the ex-post assessment, we sought the opinions of the local leaders and residents of Porto Rico, most of whom stated that the dam managers disregarded the impacts they suffered and had turned a deaf ear to their claims

1 According to the Brazilian historian C.A. Dutra (2008), after a long history of forced removal from their lands due to the encroachment of settlers across Matto Grosso do Sul, between 1992 and 1997, the FUNAI (the National Indian Foundation) gave 1967 hectares of their ancestral lands to the last members of the Ofaiê Xavante Indian tribe, in the municipality of Brasilandia. In 1997 this small group (18 families) were again displaced due to the construction of the Porto Primevera dam. Although a compensation agreement was reached between the FUNAI, the CESP and the Ofaiê, in 2002 the CESP had to be forced by the Brazilian state prosecutor to pay the agreed economic and social compensation .

for compensation[2]. It should be noted that due to the Brazilian legislation of the time, the Environmental Impact Assessment (EIA) of the Porto Primavera dam project concentrated on effects in the submerged area and populations affected by flooding. Thus it did not include the study of environmental and social effects emerging after completion and downriver.

The negative effects reported by the local population have been confirmed by various studies. The dams represent a barrier to migratory species (Okada et al., 2005). Also, the artificial alteration of seasonal variations in river flows –causing a decrease in water levels– seriously affects fishing, especially in spawning periods, when fish need a greater volume of water to swim up the streams and gullies where they lay their eggs (Ulloa, 2006). The proliferation of water weeds as a result of the dams has been highlighted in various studies, such as those by Agostinho et al. (2004), and Train et al. (2005). Lastly, in their study Díaz Peña and Stancich (2000) link erosion of the Paraná River margins to alterations in flow rates stemming from dam operations. Thus these environmental effects also become social effects as they impact on communities living from fishing or agriculture.

In order to address the characteristics of the case under study we developed an ex-post assessment by using the *Social Impact Management* approach, with collective production of causal maps as our key tool. Combining tridimensional analysis (longitudinal, relational, and contextual) with causal maps makes it easier to identify areas of action where measures for more appropriate and fairer impact management may be put forward. Analyzing not only impacts caused by the building of the two dams but also by their subsequent management and effects downriver enabled us to include the longitudinal dimension in the ex-post assessment. The field work was implemented between 2009 and 2011, a decade after the dams became operational.

4. Method

The methodological strategy of the present study brings the principles of *Social Impact Management* to the ex-post assessment. The study was structured in two parts. Firstly, an analysis of the historical, economic, social, and political context through documentary analysis and in-depth interviews carried out between 2009 and 2011[3]. Choice of interviewees was made through a non-probabilistic intentional strategic sample based on six categories each reflecting a social group discursively or materially related to dam construction. The groups were: 1) those directly affected by the building of the dams, 2) university researchers, 3) NGOs, 4) public sector technical experts, 5) dam construction companies and large final consumers of hydropower, and 6) local and regional politicians. For the intragroup selection of interviewees a "snowball" strategy

2 See the video documentary "Porto Rico do Paraná", Antonio Aledo and Hugo García-Andreu, 2008. University of Alicante (Spain), State University of Londrina and Auracaria Foundation of Investment and Research in Paraná. Available online at http://hdl.handle.net/10045/17579

3 These interviews were carried out in the frame of the project "*Caracterização Geomorfológica e Hidrogeoquímica das ilhas Porto Rico e Mutum no alto Rio Paraná"* led by Dr. José Paulo Peccinini Pinese of the State University of Londrina and financed by the Auracaria Foundation of Investment and Research in Paraná (Brazil). An audiovisual excerpt from some of the interviews can be seen in the documentary "Porto Rico do Paraná" available online at http://hdl.handle.net/10045/17579

was chosen. The final number of interviews (48) was not, therefore, an aprioristic selection but the result of a process of theoretical saturation, a criterion customarily in use in non-probabilistic sampling. The information gathered in this phase provided us with the contextual dimension, affording correct interpretation of the collective causal maps, the second part of the strategy, explained in more detail below.

The meetings for the production of these causal maps took place eleven years after the inauguration of the dam of Porto Primavera. The production of the collective causal maps was divided into the following phases: 1) identification of the local social groups most likely affected by the dam (Typological Classification) and, 2) creation, by representatives of these groups, of causal maps of the main socioenvironmental impacts caused by the dams becoming operational. These successive phases when combined afforded a valuable way of registering local perceptions and experiences reflecting the responsibility of the Porto Primavera and Rosana dams for changes undergone by the river having significant social effects at local level.

5. Development of the typological classification of affected groups

If one accepts that dams, like any other megaproject, are, apart from major engineering works, sociopolitical processes in which models of regional and local development are instrumentalized in practice (Flyvbjerg et al., 2005), one should also concede that management of impacts produced by dams should be open, democratic, and participative (Fischer, 2000; Webler, 1995).

In Porto Rico, as in any other community, not all community members have the same interests and concerns. In order to bring together the greatest possible number of points of view, local society was segmented into homogeneous affected groups reflecting the following socioeconomic sectors: tourism, real estate (second home building), fishing, agriculture and livestock, retail, public administration, and the unemployed population. This segmentation was based on a series of previous interviews with local informants. We interviewed the mayor (responsible for the economic area) and councilors for the environment and tourism, a hotel manager, the manager of a real estate agency, various working and retired fishermen, agriculture and livestock managers (one working and another retired), agricultural laborers and owners of smallholdings, the manager of a boating company, and the manager of a supermarket. As Valles states, when we talk about sampling in qualitative research it is useful to segment the local community into theoretical categories, with the purpose of "creating an initial classification system similar to operations used to stratify and establish quotas in surveys by sample" (2003: 210).The creation of these categories attempts to reduce local complexity and heterogeneity by building artificial groups based on shared features (similar position in the social structure). Naturally this does not mean that all individuals in the same group necessarily share the same ideas about the causes of change in Porto Rico, but it is highly probable that they will have similar perceptions and, especially, that these will be different from and complementary to those of other affected groups.

6. Creation of the causal maps

doi:10.1016/j.eiar.2015.07.004

A causal map is a subclass of cognitive maps whose purpose is to display knowledge of a specific area in the form of causal nexuses (Miles and Huberman, 1991; Weick, 1979). The key opinions, ideas and/or questions in the problem under study are represented as nodes connected in a network by arrows indicating the direction of causality. The analysis of causality is an essential tool in social assessment, especially when it comes to making connections between bio-physical and social variables (Taylor et al., 2004). These linkages, called webbing and chaining by the authors, are "much more analytical than the compilation of a matrix of project variables set against impact variables sometimes used by assessment teams" (Taylor el al. 2004: 64). Our paper follows the same analytical process, but applied during the ex-post assessment phase. More recently, Perdicoúlis and Glasson (2006) have stressed that instruments derived from causal networks, such as causal maps, are ideally suited to SIA. According to these authors, and these conclusions can be perfectly applied to ex-post assessments, causal maps are especially appropriate in satisfying the underlying principles of impact assessment, that is, transparency, integration, and systematicity. Causal maps contribute to increasing transparency by identifying the multiple elements making up the field of study. The ability of causal maps to interconnect environmental, economic, and social dimensions allows us to increase the integration necessary in impact assessment. By covering the various phases of assessment, i.e. the identification of impacts, the monitoring of particular central elements and the proposal of alternative and mitigating measures, causal networks offer systematicity. All of this means that causal maps represent an especially appropriate tool for applying the contextual, longitudinal and relational analyses required in the *Social Impact Management* approach. They also possess a series of other advantages, such as simplicity, clarity, abstraction, and aggregation (Perdicoúlis and Glasson, 2006). However, these authors also state that, despite these benefits, in recent years causal networks have been very rarely used in these methodologies. There appears to be a vicious circle whereby their recent scarce implementation at the same time diminishes their appeal for current application. In the specific case of SIA various authors stress the usefulness of causal maps. This is the case of Van Schooten et al. (2003: 104) for whom "following the itineraries of impact, or causal chains, and specifically thinking about the interactions which may be generated, we can identify the whole range of impacts."

Following Hodgkinson and Clarkson (2005) we can envisage two major types of procedures for building causal maps: indirect and direct. In indirect procedures it is the researcher who builds the causal map based on information provided from both primary and secondary sources (for example, analysis of textual networks: see Diesner and Carley, 2005). In contrast, direct procedures require the involvement of the participants in building the causal map. In the latter case it is customary to create the causal maps in groups (Ackerman and Eden, 2001). In this way the causal maps represent a shared point of view on the subject analyzed, once the varying positions have been debated. Using this method it is much easier than with other qualitative techniques to reach a consensus between participants with differing points of view (Albino et al., 2002). Also directly produced collective causal maps have the advantages that their content is defined by participants using their own terminology instead of that imposed by the researcher (Weick and Bougon, 1986: 1) and that working with data from multiple individuals can reduce the presence of bias.

In the present study, the causal maps of the main socioenvironmental impacts of the dams were created collectively at a meeting where 45 representatives of the categories included in the typological classification were present, except those from the government team. The latter were excluded in order to avoid them inhibiting the other participants' freedom of expression. The list of people invited to the meeting was drawn up using the snowball technique: we asked the interviewees from the previous phase to put forward the names of possible participants. In total 62 individuals were invited, of which 45 attended.

The team of sociologists from the University of Alicante trained four students from the State University of Londrina in the technique of producing causal maps and in mediation in group meetings. These students acted as animators at each of the seven work tables into which the meeting was organized. The role of these mediators involved promoting dialogue, keeping discussion to the point, and ensuring that the rules of interaction and communication were followed to allow the expression of all points of view as the causal maps were drawn up. Previously to this, the study was presented to the participants and they were introduced to the technique of causal maps.

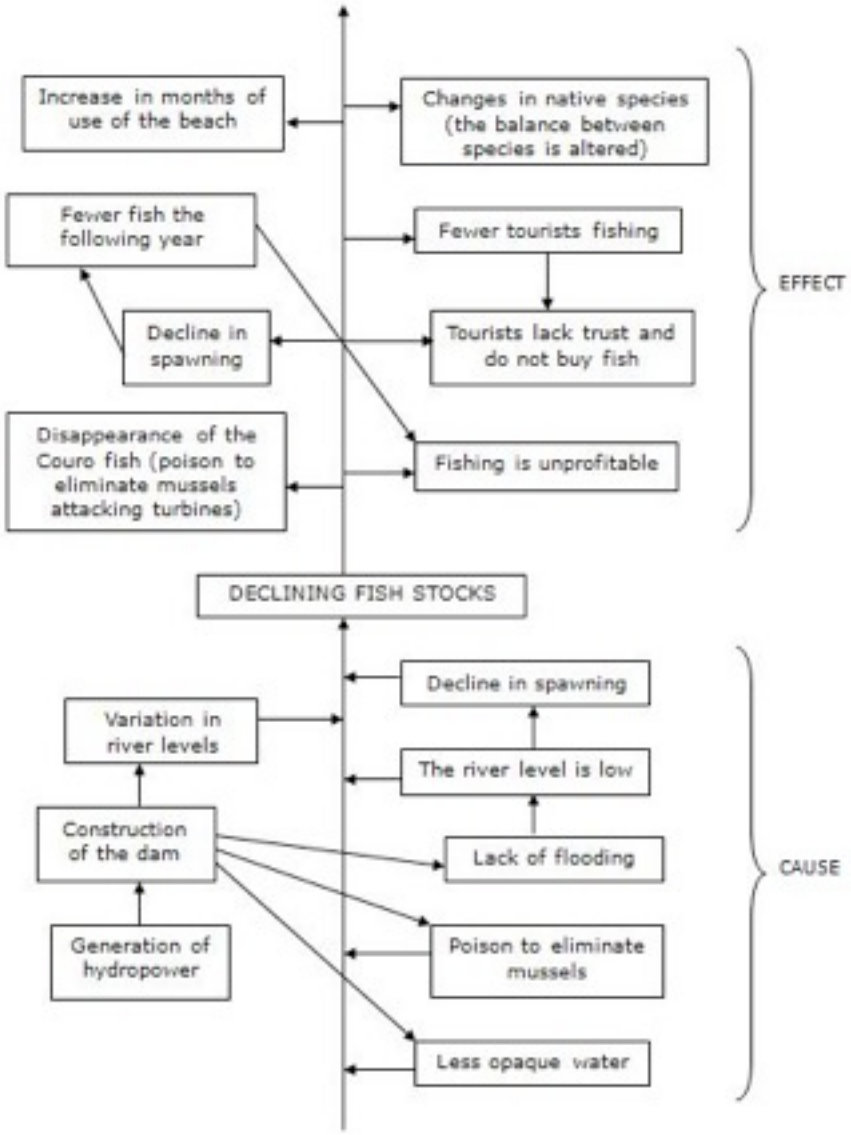
Once the study and the causal maps technique were presented, we asked participants to indicate the main changes that Porto Rico had undergone due to the building and operation of the Rosana and Porto Primavera dams. From the ensuing debate, participants picked out seven changes: the death rate of fish, the appearance of weed in the river, tourism, the increase in river pollution, the increase in sedimentation on the river bed, and the decrease in river spates and flooding. The 45 participants were divided into two working groups composed of 3 and 4 work tables.

Through a process of discussion and analysis, participants represented the causes and effects of the seven selected changes in the form of causal maps. As figure 1 shows, the nodes and their causal relationships give the map an hourglass shape. The specific impact chosen is placed in the center, into which flow all of its causal relationships (situated below it) along upward vertical lines; while its effects (situated above it) flow upwards out of it. In this way the causal sequence of a specific impact is laid out visually: information produced by participants is given form in the skeleton of the causal map, consisting in the impact (in the center) and two lines of development perpendicular to it: one representing the flows of the impact's causes, and the other of its effects. Onto this skeleton participants' knowledge is grafted. Representing their contributions in graphic form creates a feedback process which helps guide the participants' analysis, based on advances made so far. In this way a working dynamic is set in motion enabling a more orderly and productive analysis to be made. The results of this analytical and organizational endeavor were seven causal maps in which detailed local knowledge of the causal sequence surrounding each of the assessed impacts was collected. It should be noted that in each of the maps relationships between the environmental and social fields appear.

7. Results and analysis

Figure 1
Causal map: "declining fish stocks"

doi:10.1016/j.eiar.2015.07.004

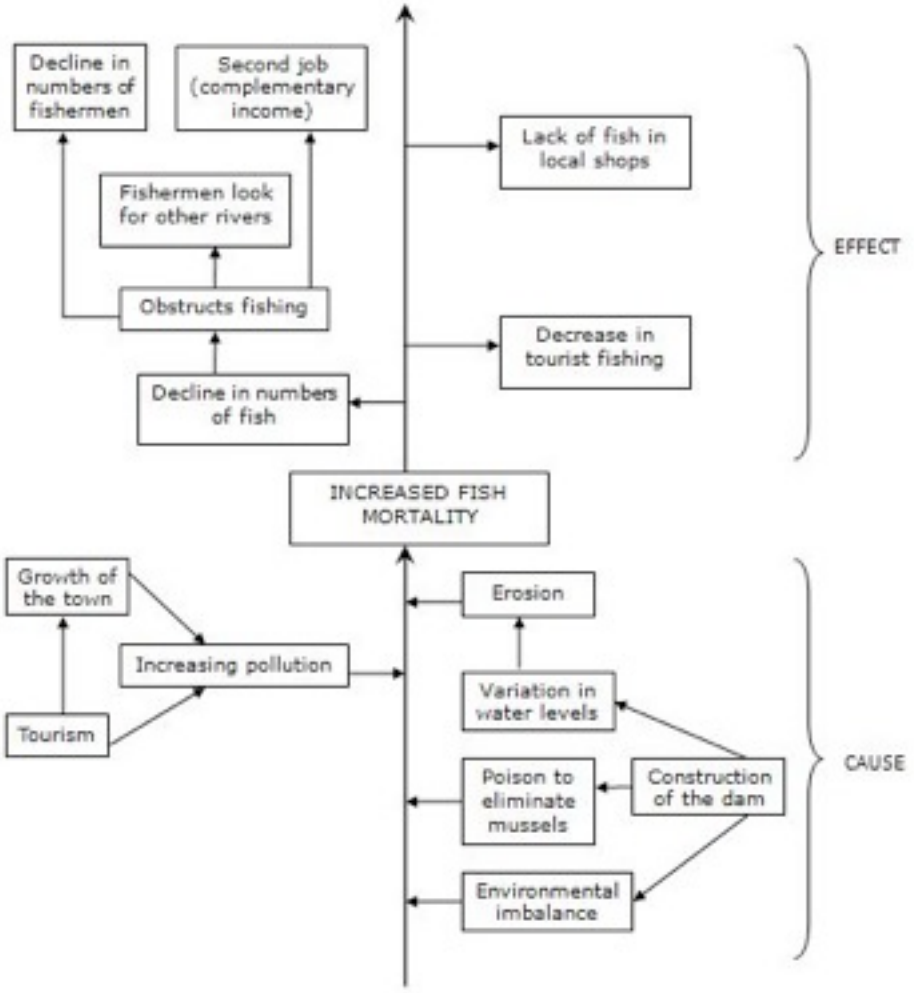


Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

In the *declining fish stocks* causal map (figure 1) it can be observed how the participants connect negative effects on fishing with the damming of the river through a series of intermediate biophysical and technical causes, such as the variation of water levels stemming from discharges from the reservoirs, the absence of floods, or the poisons used to clean the dam turbines of invasions of tiger mussels. The participants joined into a chain a sequence of facts occurring in the river to put forward their explanation of the causes and effects of this particular impact. The dynamic of the creation of the causal maps thus helped the participants to identify both the positive and negative consequences of declining fish stocks on a growth activity in the town, namely tourism. In fact in this causal map we can already glimpse one of the most important consequences which the damming of the river has had on the town: the change in its productive model from primary sector predominance to a service economy. For decades a small tourist trade based on recreational fishing had existed. However with the construction of the dams a new type of tourism benefiting from the growing beaches has taken its place. In this way the economic impact of the decline in fish stocks is compensated for by the growth of this new business. In the causal map we can also see

that participants share the official view of the social necessity of hydropower for Brazil, a recurrent cause in the maps drawn up in the workshop, justifying the construction of dams despite their ecological impact.

Figure 2
Causal map: "increased fish mortality"

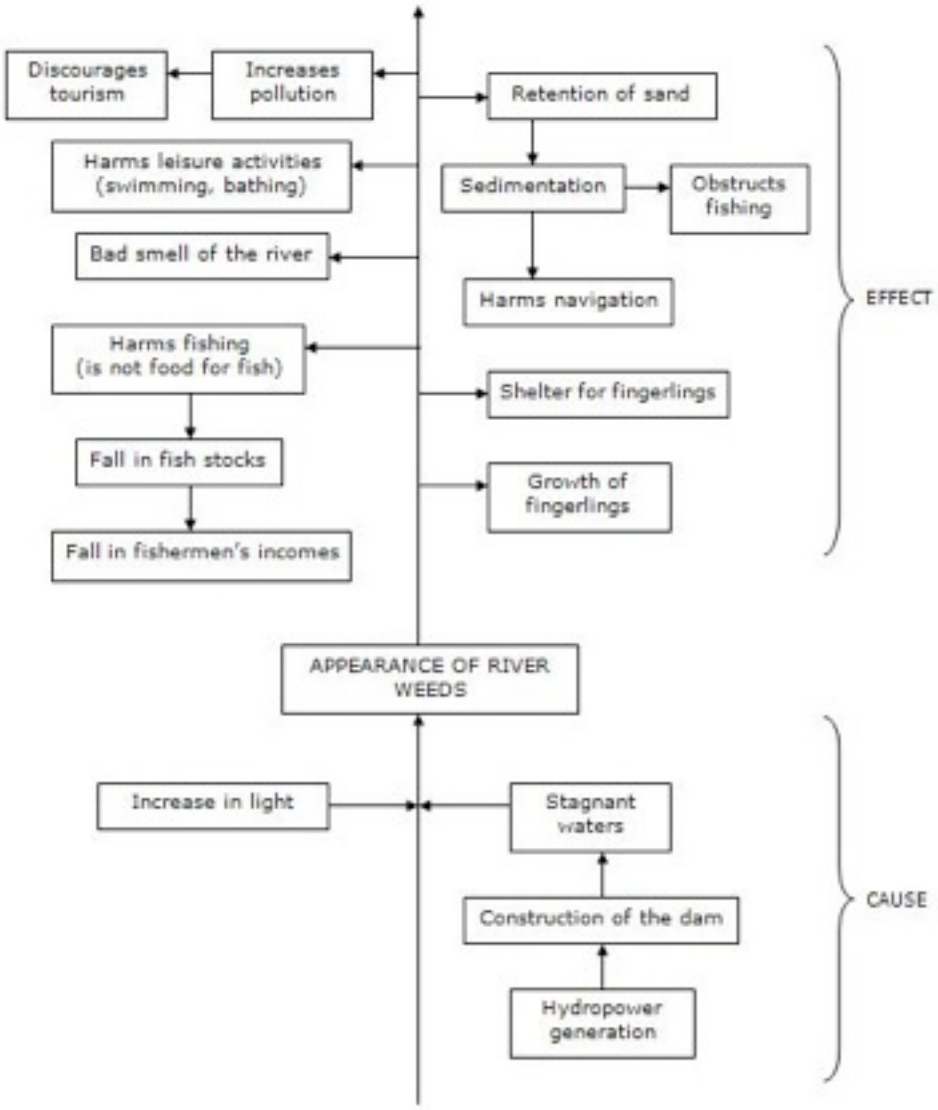


Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

According to the participants another of the main effects of the damming of the river was *increased fish mortality* (figure 2). The importance given to the condition of the river by a traditionally fishing community, and their concern for it, lies behind the identification of two very similar impacts during the meeting. There are some differences between this map and the previous one (figure 1). Among them, it is worth stressing the negative view of tourism in this map (figure 2): here it appears as a cause of the death of fish due to the water pollution it engenders.

Figure 3
Causal map: "appearance of river weeds"

doi:10.1016/j.eiar.2015.07.004

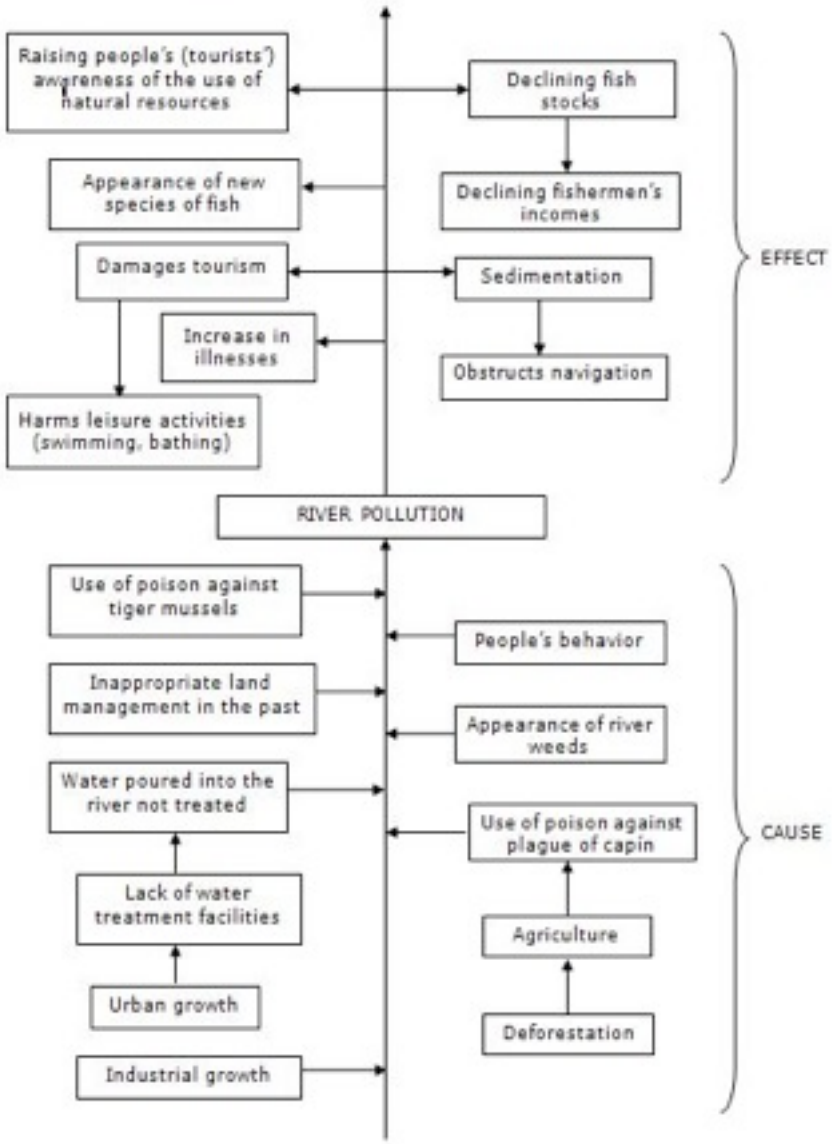


Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

The *Appearance of river weeds* (figure 3) was another of the impacts discussed at the meeting. Participants related the appearance of weeds with the slowing of the river flow due to the holding back of waters in the reservoirs. The orderly sequential analysis which preceded drawing up the causal map enabled them to set out in a clear form the ambivalence of the effects of the proliferation of weeds. In relation to fishing, on the one hand, the weeds worked in favor of the breeding of stocks, since they acted as shelter for fingerlings. In contrast, they obstructed navigation of fishing vessels, as they held sand in suspension and worsened sedimentation. The appearance of river weeds also has conflicting effects on tourism. Increased sedimentation caused by the weeds obstructs yachting, while at the same time accelerating the growth of beaches.

Figure 4

Causal map: "river pollution"



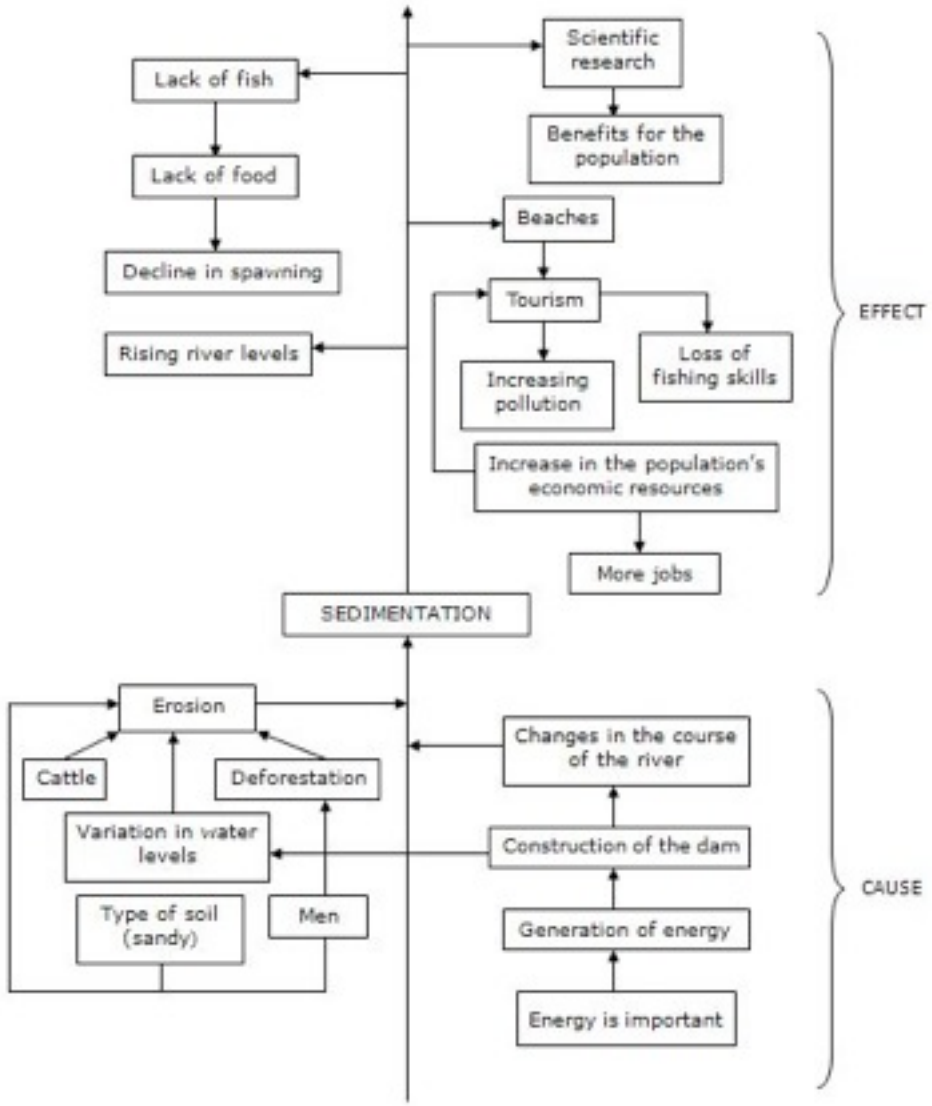
Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

The population taking part in the meeting also stressed the *pollution of the river* (figure 4) as a negative consequence stemming from the building and management of the dams. This they related to the appearance of weeds and to the use of poisons against plagues of tiger mussels. The pollution directly affected fish populations, which were reduced or substituted by other less commercial stocks and, in consequence, damaged fishermen's livelihoods. The pollution of the river also undermined the quality of bathing water for tourism, seen as the trade which should substitute fishing as the town's main source of income and economic engine.

Figure 5

Causal map: "sedimentation"

doi:10.1016/j.eiar.2015.07.004

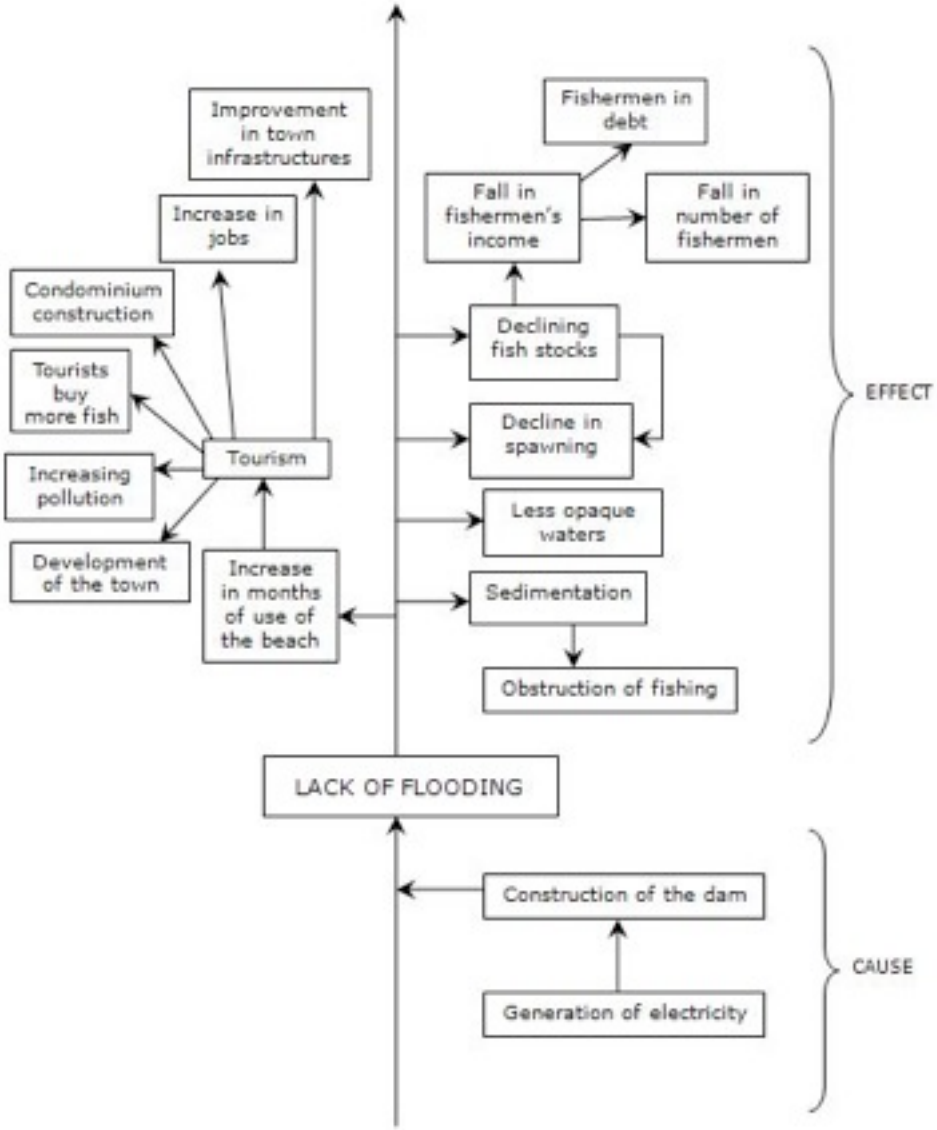


Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

The *sedimentation* of the river (figure 5) was an important issue for the interviewees. Apart from being one of the seven prioritized impacts, it appears recurrently in the other causal maps created. In this map, participants stressed a double cause for this process. On the one hand, they emphasized the alteration of the river flow by the dams. On the other they also indicated their own responsibility for the *desmatamento* or deforestation of the river margins in favor of agriculture and livestock breeding. Elimination of the gallery forest caused riverbank erosion, giving off elements in suspension which became sedimentation along various stretches of the river. Ribeiro da Silva (2002) describes the danger that the silting up of the riverbed represents for the proper working of the river's ecosystems and its various social uses. The Paraná has been undergoing a rapid process of sedimentation since the dams were built on this section of the river. However, in the causal maps sedimentation has ambivalent effects. On the one hand, it harms fishing while on the other it drives the development of tourism as it extends the beaches available as a result of increasing deposition of silt and sand. Thus in the case of sedimentation the consequences are seen as negative if the impact is analyzed from the standpoint of one particular economic and social model, in

this case fishing. But when the role played by sedimentation in the growth of tourism and its ancillary services is considered, the effects are assessed positively.

Figure 6
Causal map: "lack of flooding"



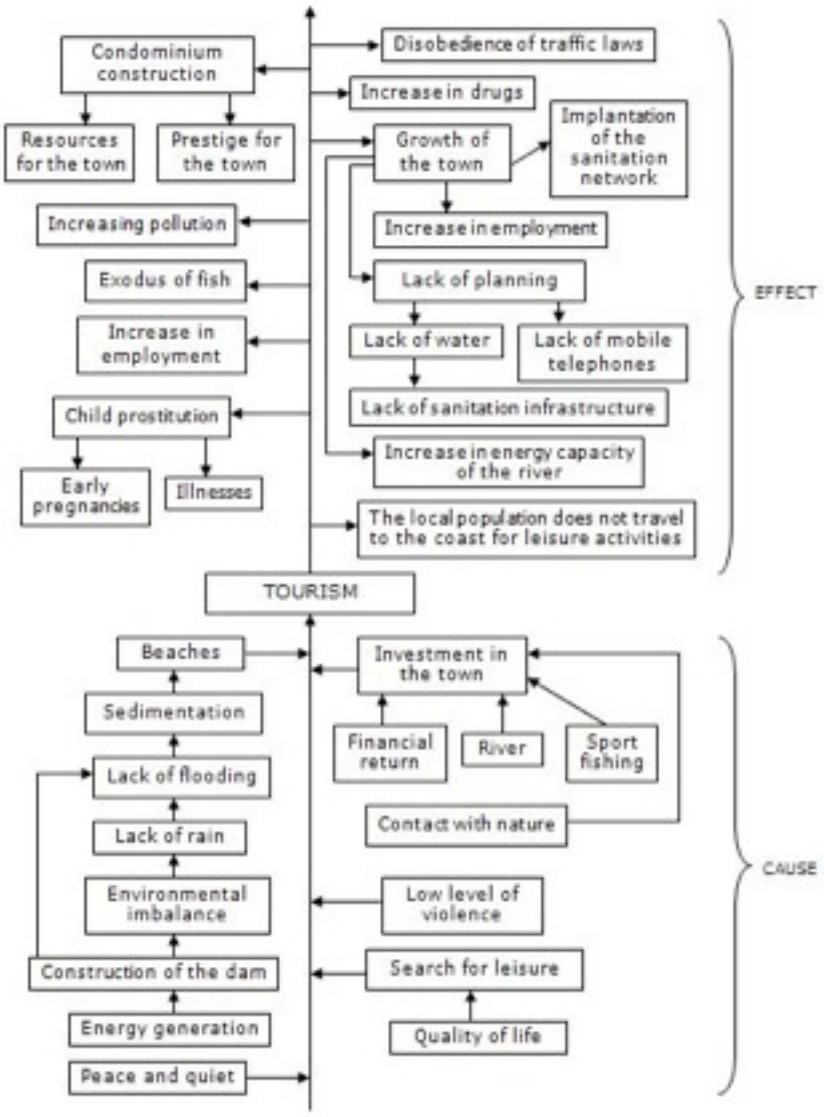
Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

Participants also chose as a prioritized impact the *lack of flooding* (figure 6) on the river during the rainiest months, as a consequence of the regulation of the river flow by the dam managers. The volume of water carried by the river is no longer conditioned by environmental causes but by social and industrial demand for electricity. This cause appears repeatedly in several of the causal networks analyzed. Fishermen participating in the meeting knew that the disappearance of high water levels entailed harmful effects for life in the river: it altered the process of spawning amongst fish and reduced the opacity of the waters with consequent negative effects on certain species. In turn, these effects had a major impact on local fishermen since catches were reduced, making fishing unviable. However, as in the previous case, this impact had favorable

doi:10.1016/j.eiar.2015.07.004

repercussions on the tourist trade as the dams regulated the flow of water and this promoted certain leisure activities on the river.

Figure 7
Causal map: "tourism"



Source: Meeting with the inhabitants of Porto Rico. Developed by the authors.

Tourism (figure 7) was the sole impact producing positive secondary effects in the town, according to participants. They related tourism to the dams in considering that the greater number of beaches and their longer duration was a consequence of the slowing of the waters and the increase in sedimentation caused by the dams. On the positive side tourism was seen as an important economic engine, able to create direct and indirect employment through tourist housing construction and other services. Thus tourism was seen as an economic alternative to traditional activities –agriculture and cattle breeding– which were in decline partly (in the case of fishing) as a result of the

dams. Although this positive assessment of tourism predominated, a critical analysis of the negative effects engendered by this new trade also emerged. Thus tourism was seen as a source of social risks such as an increase in drug consumption and the appearance of child prostitution. The participants also pointed out the importance of tourist and urban development being accompanied by planning to ensure the construction of the new infrastructures and services required.

In general terms the seven causal maps drawn up by the local inhabitants show the process of change into which the town of Porto Rico has been plunged. The damming of the river and the management of its flow to generate hydropower have produced a change in the exploitation of this resource by riverside residents. Up to very recently the exploitation of the river for fishing was the base of their economic and social organization. This dependency on the river means that the population has been strongly affected by the changes undergone by the river due to its damming. This is strongly evidenced by the fact that most of the effects identified in the causal maps are still linked to fishing. However some of the changes which have turned fishing into an economically and socially less profitable activity are also behind the growth of tourism. The control of water flows stemming from the hydroelectric plants makes the river more available for tourist exploitation (use of the river for bathing and recreational fishing, amongst others). Porto Rico seems to be facing economic restructuring, stimulated or compelled by the damming of the Paraná River, into a service economy, with the creation of new jobs in the tourist trade and second home building.

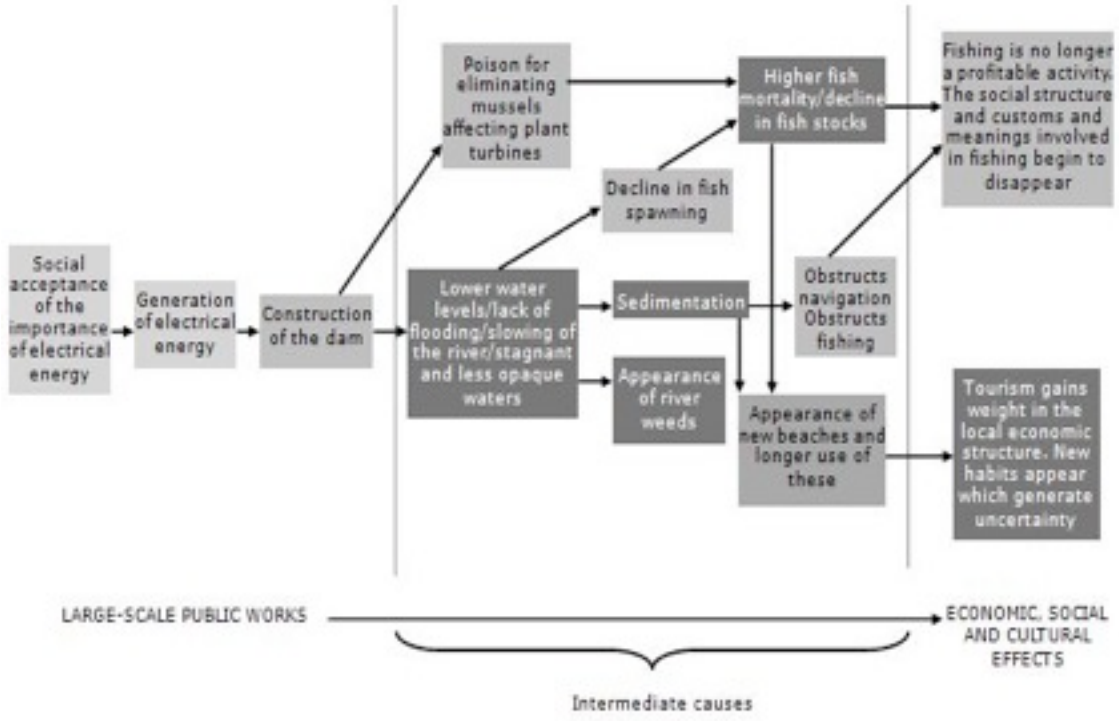
8. Discussion

Causal maps as tools in ex-post assessment achieve their potential when the contextual, longitudinal, and relational dimensions converge in their analysis. To favor this tridimensional analysis in figure 8 we show a causal map drawn up by the researchers synthesizing the seven causal maps produced in course of the study. In this causal map the longitudinal dimension is made visible when the map reflects the effects which, some years after the construction of the dams, have appeared in Porto Rico and which have caused its socioeconomic transformation; the relational dimension when the interactions emerging between the physical and social environments are made explicit; and the contextual dimension when we include sociocultural factors participating in the design and execution of the project, such as social acceptance of hydropower or the appearance of tourism. Also, contextual analysis allows us to interpret and give meaning to the entirety of the information contained in the causal map. Thus it should be noted that projects are not merely technical exercises: in their design, execution, and operation a whole set of social and institutional elements intervene which influence the decision-making process in their management and the social distribution of their consequences. For example, the effect of the appearance of beaches becomes meaningful when it is contextualized within the framework of the spread of leisure and tourism as a widely distributed social value. Likewise, the social acceptance of energy must be seen in the context of the neo-extractivist policies of Brazilian governments. It should be understood that, in the last instance, tridimensional analysis of causal maps as a part of an SIA has as its objective the identification of windows of intervention where measures of elimination, mitigation, and compensation of and for negative social effects on

doi:10.1016/j.eiar.2015.07.004

communities can be proposed. These analytical orientations are explained in the following paragraphs.

Figure 8
Map of intermediate causes. Opportunities for action.



Source: Meeting with the inhabitants of Porto Rico. Drawn up by the authors based on the combination of the 7 causal maps.

In Brazil there exists a hegemonic view which links the elimination of poverty to economic growth, for which the increase of energy is seen as necessary, energy which the country has traditionally obtained by damming its huge rivers[4]. The simplicity of this view, its majority support amongst the population, and its restriction to the technical-engineering field have meant that for years the negative socioenvironmental impacts suffered by traditional riverside communities have been seen as inevitable and affordable collateral effects.

However, this supposed inevitability may be questioned using assessment processes which include complexity as a fundamental element in their analysis. The *Social Impact Management* approach sees LPW not only as engineering mechanisms but also as processes of social change and conflict, and therefore does not limit the scope of debate and argument to merely technical questions. As the specialized literature (Perdicoúlis and Glasson, 2006; Van Schooten et al., 2003) indicates, the use of causal maps in ex-post assessment makes it easier for us to identify the multiple

4 See the video documentary "Water speech: energy, power and inequality in Brazil", Antonio Aledo and Hugo García-Andreu, 2011. University of Alicante (Spain), State University of Londrina, Auracaria Foundation of Investment and Research in Paraná and University of SENAC-Sao Paulo (Brazil). Available online at http://hdl.handle.net/10045/25127

factors bearing on the causation of the impacts studied. This detailed sequencing of the causal process of LPW impacts (enriched by the tridimensional vision afforded by *Social Impact Management*) can reveal the existence of intermediate causal elements which would have passed under the radar of other assessment techniques customarily used in SIA (such as impact checklists, which either reduce or eliminate altogether factors mediating between causes and effects). These intermediate factors at times have a political nature, and are not as exclusively technical as dam management companies would have us believe. They therefore represent arbitrary decisions and not unavoidable technical measures. In other words these "simulatedly" (Blühdorn, 2002) technical decisions respond in the last instance to the sway of particular interests; their political nature flows from a mercantilist logic aimed at extracting the highest profit by suppressing the appraisal of environmental and social costs. The identification in collective causal maps of these intermediate political and arbitrary elements means that we can establish windows of intervention, that is, opportunities for the social management of the negative impacts of LPWs. A space is opened up for the proposal and negotiation of alternatives to avoid, reduce, mitigate, or compensate the negative impacts produced by dams, in line with the principles of *Social Impact Management*.

It is from this optic that the study was designed and the whole set of causal maps created in Porto Rico analyzed, with the graphic results illustrated in figure 8. On the left, in the first third of the figure, the main cause of the impacts appears: the "Construction of the dam" and the causes lending social legitimacy to the LPW. In the last third, on the right of the figure, the economic, social, and cultural effects produced by the dams are shown. It is possible to act on all of these effects, boosting some and mitigating others, since we have identified mediating elements of the causal chain which are political, resulting from decisions based on values and interests and not determined by neutral, exclusively technical reasons. These causes appear in the central third of the figure, where the intermediate causal factors are grouped.

Amongst all the intermediate causes reflected the following variables stand out: "Lowering of the level of the river/lack of flooding/slowing of the river/stagnant and less opaque water." These causes are actually effects of a common cause stemming from regulation of the river flows, which is not an exclusively technical process. This intermediate factor is of a political nature in which we can intervene and which, also, would have important repercussions on the effects described since it is highly dependent, given that it can be changed, and influential, given that it is responsible for a large number of the impacts.

The values underlying the way the discharge of reservoir water is managed respond to a logic which reduces the complex reality of the management and handling of the water flows and of the dam to their economic dimension. Thus the way water is released takes only energy production into account, and is therefore a decision founded on the interests of hydropower production, which can in no wise be seen as unavoidable fact. Counter to this mercantilist logic, other local and environmental logics (CIP-Ecosocial, 2011) have emerged which could be built into dam management. These are founded on fishermen's local knowledge of the workings of the river ecosystems, with a closer approximation to the natural process of ebb and flood to which both fish populations and human communities have adapted through a long process of coevolution. The incorporation of these logics via participative management of river

basins (Dourojeanni et al., 2002) could result in a closer balance between the needs of hydropower production and the natural rhythms of the river necessary for the conservation and maintenance of biodiversity.

9. Conclusions

The goal of this paper is to improve the ex-post assessment of the complex social transformations triggered by operation hydroelectric power plants. The use of causal maps built on local knowledge allows us to identify the detailed sequencing of multiple factors bearing on the causation of the social impacts studied. In order to produce hydroelectric energy, the river flow must be controlled. This control clearly performs as the most central factor in the generation of the ex-post social impacts. Moreover, two crucial effects have been uncovered thanks to the detailed sequence of causal relations gained from the analysis. On the one hand, long term unforeseen impacts have been identified such as the appearance of new economic opportunities related to for new beaches and their tourist exploitation. On the other hand, our analysis evidences the political intention in the management of the river flow. Thereby the conflict between the economic interests of CESP and the rights of the local community become clear and explicit. These outcomes could improve future SIA on dams by considering them into the scoping stage, and they would lead to more participative and democratic ways of managing the social impacts resulting from the operation of the hydroelectric power plant.

In the case of the Porto Rico community, the impacts produced by the Porto Primavera and Rosana dams on the river flow and wildlife have had a disastrous effect on the fishing community. However, these effects and the social groups involved were not included in the operation of the dams. The effects were disregarded by bodies responsible for monitoring dam operation, and therefore communities downriver from the dams were left out of measures of mitigation and/or compensation. And as a result compensation for these social and environmental costs disappeared from the economic balance-sheets. This unequitable impact management could be better explained if we take in account that this LPW was initiated during the military dictatorship in Brazil. At that time, EIA was not mandatory. Since then, the Brazilian environmental legislation has advanced considerably. However, some authors who have analyzed the present licensing procedure in Brazil (Hanna et al., 2014; Zhouri, 2008; Glasson and Salvador, 2000) point out that there is a broad gap between the procedures established by law and their application. These authors have identified a number of problems and errors related to institutional and practical factors. Among the institutional factors, they point to excessive centralization and state-level economic and political pressures on the licensing process. With regard to practical ones, they point out the scarce participation of local actors in scoping and monitoring phases. Also these scholars place particular emphasis on the limited influence of public hearings on the design and implementation of dam projects.

Obviously, advanced environmental legislation does not necessarily ensure good practice. Therefore, it is necessary to incorporate principles of governance into the environmental licensing procedures of dams for fair and adequate implementation, laying stress on strengthening respect for the interests and preferences of the most

vulnerable groups (for more details see Esteves, Franks, Vanclay 2012). Among the variety of means that the specialized literature offers we could highlight the FPIC principles (Free Prior and Informed Consent) that have been developed for interventions affecting indigenous or native populations (Hanna et al, 2014; Doyle and Cariño, 2013). Franks et al. (2009) provide other strategies for managing social impacts caused by mining companies in English-speaking countries. Finally, the principles of collaborative governance offer a further approach, especially adaptable to impact assessment. Their suitability stems from their consensual establishment of the rules regulating participation of the public and private actors involved in each project. Thus the methodology outlined in this paper can contribute to better governance in the phase of monitoring dam operations in the following ways: 1) bringing into question the inevitability of the technical measures and by unmasking its political intention, 2) by promoting deliberation among the stakeholders, 3) by organizing traditional knowledge, thus facilitating dialogue with expert and scientific knowledge, and finally 4) by channeling the participation of the most vulnerable so that their interests are taken into account in the control of the river flow performed by the managers of the hydroelectric power plant.

The causal maps were built in participatory sessions in order to introduce local knowledge in the ex-post impact assessment phase. Although, it does not guarantee the production of strong certainties, the combination of different strategies in our approach to the object of study allows us to reduce levels of uncertainty. The information gathered through community participation is validated in other scientific and technical studies using more traditional scientific methodologies, which have yielded extremely similar results. And in our discussion of methodology we should not forget that traditional scientific knowledge applied to socioenvironmental management of the impacts of dams is also incapable of producing absolute certainties. For example, despite various studies of the effects of dams on river wildlife in the High Paraná there still remain many grey areas; for instance the results of mitigating measures aimed at easing the passage of fish through the reservoirs are still unknown (Agostinho and Gomes, 2002; Agostinho et al., 2004). Likewise, it would also be desirable to make a critical assessment of calculations of the economic benefits put forward to justify the construction of the dams[5].

Also, the systematization of information-gathering, the selection of informants, and the reflexive process of network building which creating causal maps involves enabled us to organize and structure local knowledge, which would otherwise have remained scarce and poorly structured. Collective creation of causal maps leads participants to reflect on and analyses the relationships they have with their environment. In this case participants recognized that certain environmental problems, such as deforestation of the river margins –which in turn causes the riverbed to silt up– stem mainly from their own wrong use of the land and were not exclusively caused by the construction of the dam; and thus a new field for mitigating action appears.

Before ending these methodological conclusions, it should be stressed that the method used embraces the heterogeneity of local knowledge and the plurality of

5 According to Lima (1999) the Porto Primavera dam was initially costed at 1.4 billion dollars, but by January 1999 this sum had risen to a total cost of 10.3 billion (in Ulloa, 2006: 72).

interests existing within the community, thus avoiding the risk of falling into an essentializing and homogenizing vision of local communities (Williams, 2004). This indicates the need for broad typological classifications which bring richness and a variety of approaches to informational input, strengthening the content of causal chains.

Turning to how the use of causal maps in this study might have been improved, it should be noted that the data collected can be broadened to reflect the varying intensity of causal influences or their positive or negative valuation. No doubt this would also enrich our analysis and help us pinpoint areas for mitigating measures. However, seeking this information during the creation of the maps would have complicated the process, especially when building them collectively. While graduating the intensities of causal influences would have enriched the maps, the qualification of causal relationships as positive or negative would not have been necessary since, by default, all the relationships of causality between the nodes on the maps are positive, that is, every arrow adds force to the causality of effects.

Acknowledgements

To the Research Center in *Liminologia, Ictiologia e Aqüicultura (Nupélia*) at the State University of Maringá (UEM), and to the financial support of the Auracaria Foundation of Investment and Research in Paraná, Brazil through projects 9527/2006, 14354/2009, and 13015/2008. The authors of this paper are very grateful for all the useful comments made by anonymous reviewers of this journal.

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