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Challenges in managing fisheries in the São Francisco watershed of Brazil

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Abstract:

Effective, sustainable governance and adequate management of socially valued, common-pool resource systems have been a major challenge to society on a global scale. With rapid population growth and intensification of resource extraction, the magnitude and number of resulting impacts and conflicts have significantly increased, particularly since the 1970s in developing countries. The present paper will discuss the multifarious situation of resource-user conflicts in the São Francisco watershed in central and northeastern Brazil. Here the situation is multi-leveled with this river crossing different ecosystems, various socio-economic systems and several state boundaries. Moreover, government agencies from different levels (federal, state and municipal) and sectors have a stake in this river management. A rapid assessment of main environmental and socio-economic problems related to common-pool resource use, particularly fisheries, has been carried out in June 2003. Through observations, interviews and focus group discussions with representatives from the local Government, NGOs and fishers' associations (*Colônia de Pescadores, Associação de Pescadores*), major conflicts and tensions have been mapped out in various communities along the river. Professional, traditional fishers seem to be the most disadvantaged stakeholder group, in the given common-pool resource scenario, because their livelihood directly depends on resource abundance and diversity. With declining fish populations most of the traditional communities nowadays live in poverty and consequently are often in conflict with sport fishers, farmers, cattle ranchers and hydroelectric power plants. The paper analyses the role of major stakeholders and their concerns with respect to resource use. It discusses the possibility of co-management to overcome stakeholder conflicts in the watershed and searches for answers to questions such as: *Can fishing accords as co-management arrangements, contribute to effective governance? What can local and regional governments do to promote co-management? What role may international bilateral agreements and international NGOs play in sustaining this resource system?* The paper finally concludes with an evaluation of the potential and hindrances regarding co-management in the specific case of the São Francisco watershed.

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1. Introduction

Artisanal fisheries in traditional riverine and coastal communities throughout Brazil are experiencing a state of socio-economic and environmental crisis due to the depletion of fish stocks, access conflicts, and socio-economic exclusion. This is not a unique phenomenon, but rather reflects a worldwide trend of collapse of small-scale fisheries management due to ineffective governance (Mahon 1997, Berkes et ali. 2001), an increasing number of resource users competing for resources and space (e.g. infrastructure development, tourism, hydropower development and aquaculture), environmental changes (e.g. pollution, river siltation, deforestation, coastal erosion), and the integration of local markets to global markets, often leading to exclusion rather than new opportunities for fishing communities (Nielsen et ali. 2002). Ineffective governance is related, among other things, to a poor performance of top-down policies based on conventional scientific management (Berkes 2003), and lack of effective government support to implement fisheries management where management institutions are rudimentary and insufficient (McGrath et ali. 2002, Seixas 2004).

Over many decades, government policies for artisanal fisheries were very centralized (top-down) and fishing communities were left out of the management process, which has undermined the legitimacy and efficacy of artisanal fisheries management (Nielsen et ali. 2002). In particular, fisheries policies tended to focus on optimizing economic return but failed to address social needs and ecological criteria (Charles 2001). In addition, artisanal fisheries management, as proposed by governments, were based on the tools and concepts developed by conventional fisheries science for large-scale fisheries (Mahon 1997, Berkes et ali. 2001); for example, using stock assessment – usually of a single species; and the idea that resource systems are predictable and reach stability. Nevertheless, fisheries are complex arrangements of interrelated social and ecological systems; i.e., fisheries are uncertain, unpredictable, and cross-scale in nature (Wilson et ali. 1994). Moreover, small-scale fishing is usually a multi-species, multi-gear activity that is part of multifaceted livelihood (including agriculture and other part-time occupations) (Berkes 2003). As a result, top-down management policies based on conventional fisheries science have not adequately addressed the socio-economic needs of fishers, livelihood issues, and the potential of fisher knowledge and participatory approach to meet these needs (Berkes 2003). The contribution of fisher knowledge for fisheries management has been reported in many world regions, such as Oceania (Johannes 1998), Canada (Neis et ali. 1999), and Brazil (Seixas & Berkes 2003a). Fisher knowledge can complement scientific knowledge to increase the information base used for decision-making, and this is particularly relevant for complex, multi-scale systems such as fisheries systems (Berkes & Folke 1998, Berkes 2003).

In this context, there is an urgent need to develop adequate policies and management strategies to ensure a socially and economically equitable and environmentally sustainable resource use among all fishing and water resource users. Otherwise, artisanal fishing communities are at risk of becoming even more excluded and losing their traditional livelihoods forever. Fishing is not only an activity that guarantees food security, but it also is important for cultural sustenance of these fishing communities (Diegues 1995, Berkes 2003).

To deal with these problems, many alternative participatory approaches to small-scale artisanal fisheries have been developed (Berkes et ali. 2001). Co-management, a shared responsibility between government, resource users and other stakeholders (Sen & Nielsen 1996, Pomeroy & Berkes 1997) is one such approach. Co-management has the potential to better regulate fishing methods, catch, seasons of prohibition, and areas (Nogara 2000, p.136), but also, and perhaps most important, to better address fisher needs and empower fishing communities (Pinkerton 1989, Nielsen et ali. 2002).

This paper explores the potential of developing and implementing co-management on the São Francisco river in Brazil. It is an output of a *rapid field assessment* of fishing communities conducted by the authors at the São Francisco river basin (Gutberlet & Seixas 2003), as part of a larger project: *Projeto Peixes, Pessoas e Agua.* The project is funded by the Canadian International Development Agency (CIDA) and involves a consortium of Brazilian and Canadian partners led by the Canadian NGO World Fisheries Trust and the Brazilian Federal University of São Carlos. It also includes other universities, governments at all levels, the *Professional Fishing Federation of Minas Gerais* and industry. *Projeto Peixes, Pessoas e Agua* works toward fisheries sustainability and improved livelihoods in the São Francisco valley, and promotes co-management as a key strategy.

Biological and ecological aspects of the São Francisco fisheries have been extensively discussed in the literature, whereas socio-cultural and economic aspects of this activity and the communities involved have been dealt with to a lesser degree (Thé et ali. 2004, Godinho & Godinho 2004, Valêncio et ali. 2004, among others). In this paper, we aim to gain a better understanding of the governance problems of the São Francisco river basin and search for possible solutions based on local stakeholders' perspectives. The focus in our discussion will be on assets of traditional fishing communities and the threads to their livelihoods and resulting conflicts between traditional fishers and other more powerful resource users.

1.1 Study site and research methods

The São Francisco river has an extension of 2.863 km and its watershed encompass seven states plus the Federal District. During June and July of 2003, we carried out field research in 11 fishing communities/municipalities in two of these states (Figure 1). We visited the following localities: Três Marias, Pirapora, Buritizeiros, São Francisco, Januária, Pedras de Maria da Cruz and Buritis in the State of Minas Gerais; and Piranhas, Entremontes, Penedo and Marituba do Peixe, in the State of Alagoas.

In each locality, we conducted a *rapid assessment* to provide environmental and socio-economic baseline data for the design of possible co-management arrangements for the São Francisco river basin. The assessment was to identify resource management issues and conflicts among the stakeholders, to discuss these with local leaders and government representatives and to search for possible solutions, including assessing local capacity and potential for co-management. The following questions were central to our analysis: What are the current trends and threats in the livelihoods of traditional fishing communities in this watershed? What are the major conflicts

over water and fishing resources? Could co-management strategies contribute to solve these conflicts? What are the current strengths and capacities of the communities?

Source:

Participative and action-oriented research, including strong interactions with members of the target communities, are important to identifying priorities amongst the problems to be tackled while searching for solutions that create a better understanding of the current situation (Thiollent 2002). The researchers were concerned about the transfer of information and the teaching of new

tools to the community, in the sense of transformative research. Recurrent issues for discussion were the fishers' organizational structure and strategies to enforce their rights. One of the direct outcomes from the interactions between the researchers and the community during the survey was the subsequent meeting of fishers to discuss the new fishing legislation (*decreto)*. Besides participative approaches in data collection, such as interviewing, group meetings and discussions, we also incorporated and referred to published and unpublished information from other researchers, after having received their consent.

The field research focused on identifying and valuing community resources, existing capabilities and limitations. We adapted in our fieldwork an *asset based community development* strategy (Foster & Mathie 2003) and a *capacity assessment* approach (Markey et ali. 2001). These methods are based on *appreciative inquire*, valuing communities' capabilities and identifying their needs. Such a perspective involves the identification and mobilisation of social capital for community development (Kretzmann & McKnight 1993).

In all municipalities and communities visited, meetings and interviews were held with leaders from the civil society and representatives of government agencies. We interviewed the head of local and state fisher organisations (*Colônia de Pescadores*, fisher associations), government agents responsible for the enforcement of regulations from the Brazilian Agency for the Environment and Natural Resources (IBAMA[4]), the State Institute of Forests (IEF[5]) of Minas Gerais, and the Environmental Police[6]. Representatives from the City Hall, municipal secretaries, local leaders, university professors, environmentalists, and NGO members were also interviewed. We further carried out semi-structured interviews with randomly chosen fishers and family members, including fisherwomen. The interview structure was open-ended and aimed to explore the socio-economic and environmental universe of local communities. Interviews were carried out individually or in small groups and lasted from 20 min to 2 hours each. The interaction with other locals and field observations further added to our understanding of the local cultural and ecological diversity. In some localities, meetings were held with large groups of fishers and government and NGO representatives. In these cases, data collection was based on focus group discussions about fisheries, the river and resource management issues at each locality.

1.2 Resource management systems

Fisheries and riverine water are classical examples of common-pool resource systems – a class of resources for which exclusion is difficult and joint use involves subtractibility (Berkes 1989, Feeny et ali. 1990). The Common property theory (McCay & Acheson 1997, Berkes 1989, Ostrom 1990, Bromley 1992, Ostrom et ali. 2002) has addressed the implications of possible property regimes under which natural resources may be managed. These include four 'pure' property regimes: state property, private property, communal property and open access (Feeny et ali. 1990) or a combination of them. An example of the latter is co-management arrangements in

[4] Instituto do Meio Ambiente e dos Recursos Naturais Renováveis
[5] Instituto Estadual de Florestas
[6] Polícia Militar Ambiental

which resource management is shared between the state (government) and local resource users – and perhaps other stakeholders.

In Brazil, all fishing resources in public water are under government regulations (i.e., *de jure* state property regimes) and according to the legislation are considered open access. Nobody can be specifically denied access to the fishery resource. Ineffective management strategies and inefficient regulation enforcement, often because government is understaffed and lacks equipment, further turns fisheries in an unprotected *de fact* open access system in most of the country. Nevertheless, open access systems are prone to fail – leading to the so-called 'Tragedy of the Commons" (Hardin 1968). In response to the open access situation and the lack of effective government support to many small-scale, artisanal fisheries, some co-management initiatives focusing on integrating community-based management (communal property regimes) and government management (state property regimes) have emerged in the past two decades in Brazil. Examples of fisheries co-management are found at the Lower Amazon floodplain in the North (Castro 2000, McGrath et ali. 2002, Castro & McGrath 2003), at reservoirs in the Northeast (Christensen et ali. 1995, Barbosa & Hartmann 1997, Hartmann & Campelo 1998), at a Maritime Extractive Reserve in the Southeast (Lobão 2000, Silva *in press*); and at two lagoons in the South of Brazil: the Ibiraquera Lagoon (Seixas & Berkes 2003b), and Lagoa dos Patos (Reis & D'Incao 2000, D'Incao & Reis 2002, Kalikoski et ali. 2002, Kalikoski & Satterfield *in press*, Kalikoski & Vasconcellos *in press*).

Brazil is a nation with a history of centralized decision-making – all fisheries regulations have to be approved at the federal office of IBAMA in the nation's capital. Hence, initiatives attempting to implement co-management in this country have faced many challenges. For instance, the question arises to what extent policy-makers are prepared to share decision-making power and accept local knowledge as a credible knowledge system that may complement scientific knowledge? To what extent are local resource users, who are accustomed to paternalistic and top-down decision-making, prepared to engage in a more participatory management? To what extent are fieldworkers (government and NGO staff, including science-trained researchers) prepared to mediate the flow of knowledge and power struggles between government agencies, resource users, and other stakeholders? In Section 5 we discuss some of these challenges based on findings from our survey and discussed in the literature based on selected initiatives of participatory fisheries management in Brazil (Seixas 2004).

2. Resource use on the São Francisco river

The São Francisco river has a long and outstanding history in providing abundant natural resources to indigenous populations. The Pankuraru, Pancararé, Atikum, Kimbiwa, Trukas and Kiriri lived in this watershed until the arrival of the Portuguese, in the early 16th Century. The indigenous population declined with the spread of infectious disease, the introduction of forced labour and armed conflicts with Portuguese explorers, the *Bandeirantes*. During the colonial period, the first riverine settlements were established at present-day Penedo, Pirapora and São Francisco. Since then, the river has provided resources to sustain fishing livelihoods and has shaped the local culture, which is characterised by hardship and endurance.

The river also played a pivotal role for the outflow of local products and the import of industrialised goods to the region. During the *period of meat and leather,* throughout the 18th Century, the region was economically thriving with cattle ranching. There were also times when the river attracted thousands of migrants from the drought-prone Northeast. There are no exact numbers, but during the famine from 1877 to 1880 hundreds of thousands of people starved to death and thousands moved into the São Francisco valley to work on the construction of the railway system, which linked the Upper and Lower portions of the basin. With the expansion of the road systems in the 20th Century, transportation shifted away from the river, driving riverine cities into an economic decline. Before this, despite the railway, the river was still the principal vein connecting towns, cities and harbours between the Upper and the Lower São Francisco (CPT/CEPAC/IBASE n.d.).

The São Francisco river originates in the mountains of *Serra da Canastra*. From there it flows 2,700km from the highlands in Minas Gerais, through the semi-arid and arid *Cerrado* and *Caatinga* ecosystem. It then cuts through deep canyons and becomes the boundary between the states of Alagoas and Sergipe, before it flows through large floodplains, east into the Atlantic Ocean (see Figure 1). Specific ecological features such as seasonally flooded lagoons (*marginal lagoons*) and gallery forests provide for the river's abundance and diversity in fish. There are still thousands of families in the watershed who traditionally depend on the river's resources. The following sections will discuss the prevailing fishing activities, some of the social and economic predicaments and a description of the main stakeholders in the use of natural resources of the São Francisco river.

2.1 Prevailing fishing activities

São Francisco fisheries may be divided in two groups: reservoir fisheries and riverine fisheries. Major target species and fishing gears used vary between these two groups. In riverine fisheries of the mid-high São Francisco portion surveyed, migratory fishes such as the curimbata (*Prochilodus marggravii* and *affinis*), dourado (*Salminus brasiliensis*) and surubim (*Pseudoplatystoma coruscans*) are the main targets. The reservoir fishery of Três Marias relies on the peacock bass (tucunaré – *Cichla ocellaris*), (retirar a pescada porque ela existe no reservatório de Sobradinho, não no de Três Marias), the small catfish mandi-amarelo (*Pimelodus maculatus*) and the curimbata (Only the last two are native species to the watershed, and only the curimbata is a "migratory" species)River fisheries in the lower Sao Franciso are dominated in volume by the curimbata and an anchovy the pilombeta (*Achoviella* sp.), though surubim and the pitu freshwater prawn (*Macrobrachium carcinus*) are the most valuable targets and higher profile (Sato & Godinho, 2003).

There are two major seasons in the São Francisco fisheries: the "clear water" season – the period with no rain – when fish are less abundant; and the "dirty water" season – the rainy season – when fish is abundant and many species are conducting spawning migration. Fishers use different gears and strategies for each season. It is during the rainy season that the water level is highest and marginal lagoons get regularly flooded.

Thé (2003) identified several gears used on the Minas Gerais section of the river (the mid-high São Francisco). These include drift gill-net (*caceia*), cast net (*tarrafa*), set hooks (*pinda* or *anzol de galho*), hook and line (*linhada*, *linha* or *anzol*), live-bait jigging (*terreina*), steel hooks (*aço*), long-line (*grozeira*), *currico*, live-bait jigging rotation (with different bait) (*rodada*), harpoon and gaff hook (*arpão*, *fisga*), as well as double-mesh cast net (*tarrafão*). The fishers provided information on the techniques and gear that results in the best fishery production for each period of the year, including information on locations where these are most effective and on the best bait for use on hooks (Appendix I) (Thé 2003).

In the Três Marias reservoir, the technique most used is the gill net, with a mean number of 24 nets per fisher (Thé 1999). Usually, every fisher has a variety of nets that cover all of the mesh sizes. The 10mm mesh-size net was the size most used, followed by those of 11 to 22mm mesh size, each one specialized for the capture of specific medium and large-bodied species. The material most used for the nets is nylon, being the most efficient in clear water. Some fishers use nets made of silk line. Even though the nets are more efficient, few fishers use them because of the high price of the material and the difficulty of cleaning them during the rainy season, when the nets also capture organic and other material. In addition, these nets are considerably heavier than other gear, making their setting and collecting more difficult.

There are other special practices that are used at specific times of the year in the Três Marias reservoir, corresponding to the changes in the behaviour of some fish species (Thé 1999). One of these is the "floating fishery" carried out with 3 or 4 silk nets with a mesh size of 18-20mm, tied one to another, with buoys every 10m to keep them afloat. This legal fishery is used primarily to catch large *curimatás* (*Prochilodus marggravvi*) during the period of dirty waters. Another practice is the "fishery by *rela*", used primarily to catch *tucunaré* during the spawning season. This is carried out with a corral of nets around a bay of the reservoir where this species spawns. The fish are then startled by hitting the water or boat with a stick and are caught in the nets as they swim away to escape (Thé 1999). While the majority of fishers admit to having used this practice, which is illegal in the state of Minas Gerais, it is questioned even amongst themselves as being too "predatory". However, some defend its legalization as a means of controlling the population of *tucunaré* (an alotocne species) in the reservoir.

In the state of Minas Gerais, most fishing activities at the São Francisco River, including the Três Marias reservoir, follow a system of "open access". Fishers camp in small groups at places located close to the fishing spots they are accustomed to exploit; resulting in the division of the river into "territories" called *acampamentos*. In these areas fishers usually spend one or two weeks fishing, cooking, sleeping and some times cultivating small crops, returning to their homes only after having caught an amount of fish sufficient to cover their expenses (Thé, 2003).

Common property systems have evolved in some river portions in the municipalities of Pirapora and Buritizeiro, and near the "beach" in the municipality of Januária. The system includes access rules and regulations for resources use, classified by Ostrom and Schlager (1996) as operational rights and decision-making rules, which correspond to rights applied for management, exclusion and alienation. So far, these local rules have not being considered by the government as legitimate community resource management (Thé, 2003).

2.2 Women and fisheries

While fishing is typically a male profession, there are women involved in the activity. For instance, Thé (2003) encountered three fisherwomen in the high-mid São Francisco amongst the total of 74 fishers interviewed. Preliminary surveys carried out by the same author at the start of 2004 indicate a rise in the number of women with fishing licences affiliated to the different *Colônias* in Minas Gerais. This trend results from a lack of work in the region and the motivation of receiving unemployment insurance equal to a monthly minimum wage (R$240,00 = approximately 86 US$) during the four months of fishery closure, in which commercial fishing activities are prohibited.

On the lower São Francisco, in Penedo (Alagoas), women use dip nets (*puça*) to catch fresh-water shrimp (*pitu*) and gillnets (*rede de travessia*) to catch fish. Recently a Fisherwomen's Association[7] has been created in this municipality in order to mobilize the women involved in fishing-related work to demand better working and livelihood conditions. This association, currently with a membership of 24 women from 13 municipalities, is affiliated to the *Colônia de Pescadores Z-12* – the local fisher organization. However, there are still many fisherwomen that are not yet affiliated to the association.

According to Marques (1992), there were only a few active fisherwomen in Marituba do Peixe, Alagoas in the early 1990's. During that time, local men considered one of these women *a real fisher*, because she applied gear exclusively used by men such as a fish trap (*covo)*, the gillnet (*rede de travessa*) and the cast-net (*tarrafa*). The rest of the women used a variety of hook-and-line with a rod (*anzol-de-vara*), *bóia, jereré-de-cabo, jereré-redondo* and without a rod (*linha de mão*). Some fishing gear (e.g., *jereré*) are used only by women. The skills taught to girls and boys in the education system are differentiated early on: the former learn straw crafting and the latter learn fishing (Marques, 1992, p. 51). Marques (1992, p. 50) concludes that men are usually in charge of fishing and women only fish when needed or when men are sick. In one of our interviews in the lower São Francisco River, a fisher mentioned that his ex-wife now fishes as a professional (full-time). Similar cases, in which women became professional fishers because they want to, or because they need to, are no exceptions. Once women get affiliated to the *Colônia*, they enjoy the same benefits given to all fishers, as well as specific female benefits such as maternity leave.

2.3 Fishers' organization and involvement in decision-making

As a result of lifelong social exclusion, the self-esteem among fishers and their families is generally very low. Fishers usually are the traditional local population, living in the area for several generations. They are descendents from Portuguese, Africans and indigenous people. This sector of society lives marginalized and has been treated as inferior by the government and the civil society. Fishers' interests are not well represented and the participation rate in policy issues and municipal decision-making, such as through council boards, is reduced or almost inexistent.

[7] Associação das Mulheres Pescadeiras de Penedo

In addition, their low formal educational level contributes to the maintenance of their excluded status and reinforces the existing prejudice against them.

Not everywhere however, are the social structures as rigid and stagnant as outlined above. There are recent examples of fishers mobilizing and exerting pressure for change. In some municipalities (Maria da Cruz, Buritis and Penedo for example), fishers, both men and women, have become actively engaged in meetings, workshops and lectures to discuss and search for solutions to their problems. Nevertheless, the history of fishers' formal organization shows an overall low degree of mobilization.

In 1982, the Federal Fisheries Agency SUDEPE[8] created the fishers' Federation in Minas Gerais. Since then fishers are organized in so called *Colônias* or fishing associations at the local level, *Federation* at the state level and *Confederation* at the national level. Some *Colônias* are well structured and apparently well organized. The mobilizing capacity, leadership and level of response of the *Colônia* to the fishers' needs vary between active and little engagement. Although the number of fishers affiliated is quite significant, many do not pay the annual fee nor participate in regular meetings and discussions. This might be the result of the fishers' lack of confidence in the mobilizing capabilities of their class to change issues of concern. They might be tired of not seeing their opinions and knowledge being used by their representatives to improve their situation. There is discredit of unaffiliated fishers concerning corruption and nepotism within the *Colônias*. In part this is the result of their perception of the "culture of corruption" in present or past administrations, but it might also be due to the lack of information. Generally, fishers are rather sceptical and doubtful about the benefits, like unemployment insurance, maternity leave, retirement payment, etc. that could be obtained from affiliation. According to Thé (2003), however, affiliation rates have grown since 2002, once the *Colonias* became responsible for distributing the Federal Government unemployment insurance to fishers during the closure of professional fisheries throughout the migratory and reproductive periods.

In Minas Gerais, the Fisher's Federation has undertaken important steps to improve their situation, such as the public hearing of the Legislative Assembly of Minas Gerais, held in July 2000 and attended by more than 2,000 fishers, to discuss fishing management. This event was an important milestone for the elaboration of the Fishing Law # 14181/01. This indicates that there is a visible rise in the capacity of fisher organizations (some *Colônias* and the state federation) to articulate and mobilize people and agencies for the co-management process. Despite improvements made through the effort of some *colônias* and state fishers' federation with regards to their organization and the access to social services, the large majority of fishers are not yet engaged in solving their problems. There is still much room to empower fishers.

2.4. Main stakeholders involved in the use of fish and water resources

The river's major fishing stakeholder groups include licensed professional fishers, informal commercial fishers, and sport fishers. In all municipalities visited there is a certain degree of organisation among professional fishers, through the *Colônia de Pescadores* or *Fisher Associations*. The way each of these organisations works varies according to their history and

[8] Superintendência para o Desenvolvimento da Pesca

engagement with fishers' concerns, but there are still many full-time fishers who are not affiliated. These are known as *"gancheiros"* (hitch hikers). Often this number is even higher than that of affiliated fishers. They carry out their fishing activity and market their products as professionals, but do not pay dues and may not have a fishing license. Unlicensed fishers can be considered as informal. They do not receive social insurance benefits; such as "unemployment insurance" during the closed fishing seasons. They often continue with their activities, risking being caught, getting a fine or losing gear.

Farming (both agriculture and cattle ranching) is practised in several parts of the São Francisco basin, sometimes extending up to the margins of the river. In the higher and middle São Francisco cattle ranching is the predominant activity. There are also orchards and annual and perennial plantations. In the lower São Francisco, sugar cane monocultures are still expanding. Most of the farms are large and their owners are usually very powerful and influential, owning alcohol and sugar industries as well and often holding close ties with politicians.

The São Francisco River is also used to generate hydroelectric energy and for that purpose the São Francisco Hydroelectric Company (CHESF) was created by a decree in 1945. It is one of the biggest companies of the electric power sector in Brazil. The company owns 14 hydroelectric plants, nine of which are located at the São Francisco River and generate energy for 42 million people in eight states in the Northeast region of Brazil. This company holds strong decision-making power concerning development issues in the Northeast. The electricity company of Minas Gerais (CEMIG[9]) controls the generation of hydroelectric energy in the higher and middle São Francisco basin, including the Três Marias plant. This company is also very powerful in decision-making concerning the São Francisco river management. However, ultimate authority for regulation of electrical generation (which in turn influences water flow and resevoir levels) lies with the federal agency ONS (Operadora Nacional das Sistemas) that coordinates the generation and distribution of electrical power throughout the country.

The Development Agency for the São Francisco Valley (CODEVASF[10]), while primarily focusing on agriculture, also promotes a variety of activities related to fishery and aquaculture in the region. These include capacity building, implementation of aquaculture projects with *Tilapia*, and, in the Três Marias region (in partnership with CEMIG) world-class research on reproduction of native fish species (including stocking of the reservoir) (Sato 2004, pers. comm.). In Xingó, CODEVASF operates a capacity building centre, a fish farming training station, and a fish processing plant. The Government sector is another important stakeholder at the local, state and federal levels. Some municipal public authorities are currently experiencing financial and political crisis due to corruption scandals, nepotism, as well as external factors, hindering and often paralysing the Government's involvement in natural resource management and social development projects.

The State Institute of Forests (IEF) sets fishery regulations for the state Minas Gerais that are supplementary to the federal regulations. The Environmental Police section of the state's Military Police enforces these. Both the IEF and the police run offices in each municipality. Most fishers

[9] Companhia Energética de Minas Gerais
[10] Companhia de Desenvolvimento do Vale do São Francisco

consider the IEF and the Environmental Police as repressive and in many municipalities the dialogue between the IEF/Police agents and fishers is poor.

Despite the fact that the federal environmental agency IBAMA has bureaus in several of the municipalities, they tend to act together with state agencies such as IEF and Environmental Police. IBAMA has not much direct action in enforcing fisheries and water resources uses in this area. A new Federal Agency for Fisheries and Aquaculture (SEAP[11]) was created in 2003. This organization is expected to play an important role in solving social and environmental problems of the São Francisco river basin.

Watershed management committees are part of a relatively new federal government policy for participatory water management. In some states, the mobilization is generating the creation of sub-basin committees. These promise to incorporate the local needs and demands into resource management. Professional fishers are represented on both the main committee and sub-committees of the Sao Francisco, though fisheries are not yet a clear priority.

3. Socio-economic aspects of fishing communities

Today, the effects of 'free trade' and increasing global integration of the economy have led to widespread social and economic restructuring. Large scale, intensive resource extraction has added to the depletion of fish stocks and conflicts over the access of natural resources in general. The livelihoods of traditional communities are affected most, since they rely on the extraction of these resources. The results are widespread vulnerability and social exclusion, whereby the degree of exclusion varies according to the prevailing environmental conditions, resource availability, number of unresolved conflicts, and level of social mobilization in the community.

The standard of living in most fishing communities is considered precarious. Only households in the city centre have access to clean water, waste collection and electricity. In all municipalities, sewage is still drained into septic tanks or diverted into the river with no prior treatment. For most of the riverine population, access to basic infrastructure only means being connected to the electricity net. Drinking water supply comes from either wells or the river itself. Uncollected household waste is burned, buried or deposited nearby and, particularly plastic is often dispersed in the landscape and remains visible for decades.

Children from riverine households usually commute by boat or bus to attend primary school. As more and more rural schools have closed lately, these children often have to travel long distances. However, many fishers commented that the Federal Government's school scholarship program (*bolsa escolar)* has encouraged the participation of rural children in formal schooling. Subsistence agriculture is important to many fishers along the São Francisco River. They cultivate food crops such as corn, bean, rice, pumpkin, fruits and sometimes vegetables in gardens next to their home or on terraces along the river floodplain. The access to the riverine areas is informally regulated by tradition. Fishers usually built a shelter nearby which is used

[11] Secretaria Especial de Aqüicultura e Pesca

during the fishing season, when they also carry out subsistence production on the small plots on terraces and nearby areas.

A significant income source in riverine communities is from fishing, though the earnings of professional fishers vary from place to place. In the municipality of Três Marias, where income levels were the highest among the communities visited, we found two different groups of fishers: reservoir fishers and river fishers. The net income of reservoir fishers varies on average between R$ 200 and R$ 300 per week (approximately 70-100 US$), while net income of river fishers lies between R$ 100 and R$ 200 per week (36-70 US$) – the minimum wage in Brazil at the time of the survey was R$ 240 per month (86 US$). Fishing expenses are about R$ 80/week. In reservoir fisheries, those who own boats and gear make much more money than fishers who work for marketing middlemen. In some cases, for example in Três Marias, fishers have improved their status by self-organizing and acquiring a place to market their product and sometimes the product from other fishers as well.

Our survey has evidenced some forms of patronage systems in some communities. According to fishers, there is often a dependency relation between fisher and middlemen or fisher and small businesses, such as cold storage plants. The latter supply the fisher with the boat, fuel, ice and even transportation to the fishing spots (sometimes a 100 km away), and in return they buy all the catch. One of the problems with such a system is that fishers may become indebted, as they cannot make enough money to pay for their costs and they enter a cycle of dependency.

The rise in status from fishermen to middlemen seems to be a reason for conflicts among professional fishers, particularly between the affiliated fishers and directors of the fishers' associations. Once a fisher has become a middleman or board member of the *colônias*, the fisher association, they may become disconnected from the class of fishers and seem not to identify any more, as they did before, with their cause. The relation has changed from belonging to the same "class" to a relation of employer and employee. This change in status that sometimes happens with fishers that have become elected into the board of *colônia* may have contributed to a process of increasing bureaucracy of the *colônias*. As a result many of the associated fishers become cut off form the institution, which should actually represent them as a professional category. The fieldwork and prior research confirm such processes where a disruption happens between the basis (the fishermen) and their representation (*colônias)* (Thé, 2003).

The fishers' income decreases the further removed from consumer centres and the more disconnected from road systems they are. In the municipality of São Francisco, the income of river fishers fluctuates, according to the season, on average between R$ 20 to R$ 90/week (7–32 US$). During the "clear water" season - the period with no rain- fish is more rare and thus more expensive. During the "dirty water" season, fish is abundant and a fisher can make up to R$ 120 (43 US$) on a good fishing day. Nevertheless, fish is becoming scarcer in recent years.

The period considered as best for fishing is the rainy season. However, professional fishing is prohibited by the state and federal government agencies for a large proportion of this season to protect the reproduction and migration of certain fish species. However, as this season has been traditionally set without local input and adaptation to actual conditions, it is a typical conflict situation where rules and laws, ecological factors and stakeholder interests need to be reviewed. The federal government has relatively recently instigated an "unemployment" benefit

(administered through the *colônias*) to compensate registered professional fishers for lost fishing opportunities during federally mandated closures of this kind, but so far any additional closures mandated by the state government are not compensated. This compensation is a vociferously defended "right" by the fishers within the areas surveyed, but is viewed through the whole range of "inadequate" to the main stimulus for taking up registered professional fishing. It is also a bonus for registered fishermen that no longer fish.

In the municipality of Januária, a fisher can also make up to R$ 90/week (32 US$) during the good fishing season. In Buritis, net income for "rotational fishing" (*pesca em rodada*) varies between R$ 150 to R$ 400 (54-143 US$) per fishing trip. However, this fishing method involves comparatively high expenses with transportation and ice. Fishers take their boat with them on a truck ride upriver; once they arrive in a certain place, they bring the boat to the water, throw their nets, and slowly float downriver for 3 or 4 days. On average they pay R$ 20 for a 5 km truck ride, summing up to R$ 100 (36 US$) or more for transportation and ice for each fishing trip.

In the municipality of Entremontes, on the lower São Francisco, fishers earn R$ 20/week during low fishing season and, in recent years, on average approximately R$ 80 during the better fishing season. The fresh-water shrimp (*pitu*) fishery, typical for this region, has declined in the last decade. In 1998, fishers in the municipalities of Entremontes and Piranhas had an average net income of R$ 100/month (Montenegro 2001, p. 3). Fishers expressed that nowadays they often capture no *pitu* at all – which is an indicator that fisheries have drastically declined. Some fishers are currently working at the Xingó aquaculture project and the processing plant, earning a salary of R$ 200/month (71 US$) (working 8h/day).

Almost at the mouth of the São Francisco River, in Marituba do Peixe, the fishers' income before the construction of the most recent hydroelectric dam (about six years ago) was about R$ 150 to R $200 (54-71 US$) per day on a good fishing day. Now, the monthly fishing income is only about R$ 80 (29 US$). The fishers are aware of the connection between the dam project and their decreased income.

Among the few alternatives to the declining earnings from the river, fishers become involved in temporary farm work. Sugar cane cutting, in the lower São Francisco, for example, yields R$24/day (8.6 US$/day) (or a little over R$500/month, approximately 179 US$/month). Other contract farm labour usually receive R$ 10/day (3.6 US$/day).

4. Change of resource use and conflicts: multi-faceted and multi-layered challenges

The fisher's livelihoods depend directly on the quality of the river. They spend most of their time on the river and hence are the ones that can identify ongoing changes in and along the river, although they may not always know the exact reasons behind these changes. Fishers, both men and women, are continuously identifying environmental impacts on the São Francisco River. The following two tables (1 and 2) summarize the main environmental impacts as perceived by local fishers.

Table 1: Major environmental impacts in some municipalities in Minas Gerais

	ENVIRONMENTAL IMPACT	Três Marias	Pirapora	Buritizeiro	São Francisco	Januária	Maria da Cruz	Buritis
water contamination	domestic sewage	yes	yes	yes	yes	yes	yes	yes
	urban waste	yes, but recycling initiative exists	yes	yes	yes	yes	yes	yes
	industrial sources	yes	textile, mineral industries					
	agriculture	yes	yes		yes	yes	yes	yes
	cattle					yes		yes
	hydroelectric plant	CEMIG						
physical alterations	damming marginal lagoons	yes	yes	yes	yes		yes	yes
	damming tributaries	yes					yes	yes
	siltation	yes	yes			yes	yes	
	altered riverbed	yes						
	irrigation	yes	yes		yes			yes
	mineral extraction				yes			
changes in natural vegetation	deforestation	yes	yes			yes	yes	yes
	deforestation of riverine vegetation					yes	yes	yes
changes in fish resources	introduction of exotic species	*Tucunaré, Tilápia*	*Tilápia* in floating tanks					
	decreasing native species	yes	yes	yes	yes	yes	yes	yes
	predatory fishing	diving and harpoon fishing, *fixga*	*litro*, fishing during closed season		*molinete*, used by amateur fishers			diving and harpoon fishing, *fixga*

Table 2: Major environmental impacts in some municipalities in Alagoas

	ENVIRONMENTAL IMPACT	Entremontes	Piranhas	Penedo	Marituba do Peixe
water contamination	domestic sewage	yes	yes	yes	yes
	urban waste	yes	yes	yes	yes
	industrial sources				
	agriculture			yes	yes
	cattle				
	hydroelectric plant	yes	yes	yes	yes
physical alterations	damming marginal lagoons	yes	yes	yes	yes
	damming tributaries			yes	yes
	siltation	yes	yes	yes	yes
	altered riverbed	yes	yes		
	irrigation	yes	yes	yes	yes
	mineral extraction	yes	yes		
changes in natural vegetation	deforestation			yes	yes
	deforestation of riverine vegetation			yes	yes
changes in fish resources	introduction of exotic species	*Tilápia*	*Tilápia*	*Tilápia*	*Tilápia, Tambaqui*
	decreasing native species	yes	yes	yes	yes
	predatory fishing	explosives and harpoon fishing	harpoon fishing	net (*rede batida*)	

4.1 Socio-environmental change and the river

Among the major changes that impact fishers' livelihoods are physical changes in the river, such as the construction of large-scale dams for the generation of hydroelectric power and the small-scale dams built for farming purposes on the outflow of marginal lakes and small tributaries. The influences of a dam on the water level may extend to hundreds of kilometres both upstream and downstream. Socio-economic impacts of a dam vary from the displacement of riverine population upstream to environmental changes affecting the livelihood of fishing communities downstream. Forced removal of people from their home and land is a universal and recurrent problem caused by dams (Trimble 1980, Porteous & Smith 2001, Gellert & Lynch 2003). Trimble (1980) has reported that social and cultural relations change with the displacement and resettlement, through the loss of the connection to place. This fact has been discussed in detail by Porteous and Smith, who observed that *…people suffer the loss of social networks and a sense of belonging to both community and the physical environment that supports their existance* (2001, p. 150).

Downstream social impacts are complex and result from the regulation of the water flow. These changes can be devastating to traditional fishing and floodplain agriculture and grazing, causing social networks and cultural traditions to deteriorate. Individuals attempt either to adapt to these changes or they relocate to areas that are more productive or offer better fishing conditions.

Upstream, habitats change from lotic to lentic. Downstream, a dam disturbs the natural seasonal floods that normally allow fish into and out of the marginal lakes – a nursery ground for many species. In addition, a dam becomes an obstacle for migratory fish – including the main commercial fish species in the São Francisco river basin. Hence, dam construction affects fish species composition, both upstream (habitat change) and downstream (lack of floods). The consequences from alterations in the water flow and the impacts on upstream and downstream environments, particularly on riverine, riparian and floodplain biota and nutrient cycles have been widely studied (Goldsmith & Hildyard 1984, McCully 2001).

In tropical floodplain systems, such as those along the middle São Francisco River, the reproduction of some fish species depend on moon-phase variations, while floods seem to be the most important factor regulating spawning in migratory species. Marginal lakes on the floodplain area, in which water level changes according to river floods, are known as natural nursery areas for many migratory fish species (locally know as *piracema* fish). The migratory fish spawn in deeper areas of the river channel and the eggs drift into the lagoons where the jung fish grow up in a protected, high nutrient environment. Hence fish stocks are directly related to floodplain integrity. Changing water regimes affect floodplain areas and in turn fish populations (Melo et ali. 2003). Local fishers are quite familiar with such factors due to their experiences; as well, scientists have known the ecology of many fish species in this area for decades (Thé et ali. 2004). Both local and scientific knowledge are, however, often disregarded or given low priority in decision-making concerning water resource uses in the São Francisco river basin.

Before the Três Marias dam was built, the river floodplains contained many marginal lakes (see research cited by Jiménez et ali. 2004, p. 379). Nowadays, fishers from the high, middle and the lower São Francisco River complain about the dams built on marginal lakes by farmers, who use the water for agriculture and cattle raising.

In addition to changing water flow, dams by hydroelectric plants also change the physical-chemical composition of the water. For example, they change the cycles of “clear water” and “dirty water”, disturbing fish spawning. In Três Marias, fishers observed a slower water flow inside the dam area and the formation of sand banks where plants grow downstream. Changes in river siltation due to increased erosion, modifies the water flow and its course and often negatively affects fishing and transportation. The lack of nutrient flow can cause problems as well. The river below a dam is known as *hungry water* or silt-free water, as this material settles out of the water column in the reservoir (McCully 2001). According to McCully (2001, pp. 34) the water that leaves the reservoir usually *starves* the remainder of the river system and the surrounding lands and coastal areas that depend upon the nutrients normally carried by the rivers. He further states that hungry water flows faster, and therefore causes the deepening of the riverbed. As the dam prevents the historical drastic floods with very high flow rates – the fish have evolved to deal with these much higher flow rates. In fact, while the river banks in some areas just below the dam are becoming more eroded because of “starved water”, the São Francisco River in general has become shallower with many new sand banks - floods that would normally clean these out don’t exist any longer. An example is just upstream of the bridge by Tres Marias, where the sewage outfall has promoted the growth of grass on substantial new sand banks. Such sand banks, even when not stabilized by vegetation, are apparently compromising spawning areas such as at the mouth of the Abaete River. Due to increased sedimentation the

traditional paddlewheelers of Pirapora are unable to operate anymore and traditional fishing practices are compromised, particularly at the mouth of the river.

Fishers from Piranhas, Entremontes and Penedo, talk about the disastrous consequences of hydroelectric plant constructions, including the Xingó plant, operated by the São Francisco Hydroelectric Company (CHESF[12]) since 1996. Change in water flow impacts on the reproduction of many fish species. In addition, the introduction of exotic and aloctone species after dam construction (e.g., *Tucunaré*) has negatively affected the natural fishing stocks in general (Montenegro et ali. 2001, p. 5). In Piranhas and Entremontes, the *pitu* fishery – which used to be the most important commercial activity in the area – became unfeasible as the needs for *pitu* to migrate downstream to the estuary for spawning, could not be met any more. Due to these well-known impacts it is no wonder that fishers in Entremontes and Piranhas for example are very sceptical and in opposition to any new dam proposal.

There are many uncertainties with the introduction of *exotic* and *aloctone* species in aquatic environments, discussed in the literature (McCully 2001). Among the concerns is that in many cases, introduced species compete with native species for food and habitat, or are predators of native species, leading to local extinction of many native species. In other cases, introduced species may carry diseases not previously faced by native species. Among the most widespread aloctone species in the São Francisco River is the peacock bass *Tucunaré* (*Cichla ocellaris*), originally from the Amazon river basin. This is a very efficient piscivorous species with parental care of its young, and has colonised the new still-water habitats created by dams, as well as many of the remaining marginal lagoons. Since 1984, when it started to appear in fishers' catches, the percentage of Tucunaré in the overall catch has been increasing considerably (Sato & Godinho 1988). *Tambaqui* (*Colossoma macropomum*) is another introduced species from the Amazon and the croaker *Pescada-do-Piau* (*Plagioscion squamosissimus*) from the Paranaíba River, is the most captured non-migratory species in the Sobradinho reservoir. Further, *Tilápia* (*Oreochromis nornorum*) is the most captured exotic species at the Itaparica dam. There are fish farming projects using Tilápia in some parts of the São Francisco River (Sato & Goldinho 2003).

According to Portaria 145/98 of IBAMA, the following other aloctone species are also present in the São Francisco river basin: *Apaiari* (*Astronotus ocellatus*), *Pacu caranha (Piaractus mesopotâmicus*), *Pirapitinga* (*Colossoma brachipomum*), and *Tambacu* (Hybrid: *Tambaqui with pacu*), as well as the following exotic species: common *carp* (*Cyprinus carpio*), silver carp (*Hypophthamictys molitrix*), nile Tilapia (*Oreochromis niloticus*), large-headed carp (*Aristichthys nobilis*), Malaysian giant prawn (*Macrobrachium rosenbergii*), and the red Tilapia (Hybrid).

Several factors have contributed to a quantitative and qualitative decrease in the native fish biodiversity, such as: changes in natural habitats and riverbed, the introduction of exotic and aloctone species, predatory fisheries and water pollution. Changes in the habitat of native species and riverbeds are primarily the results of: damming the river for hydroelectric power generation and transforming lotic environments into lentic ones, impeding fish spawning migration (*piracema*); and damming the marginal lakes for farming purposes. These lagoons are the breeding grounds for many fish species.

[12] Companhia Hidroelétrica do São Francisco

As a fisher puts it, "*The life of a fisher is quite difficult; one day you catch, the other you don't. Every day things become worse. Before the dam, I was able to catch 30 kg of fish; nowadays, if I catch 5 or 8 kg that is a lot*". According to some fishers, large migratory species such as *Surubim* (*Pseudoplatystoma coruscans*) and *Dourado* (*Salminus brasiliensis*) are the ones that are decreasing the most.

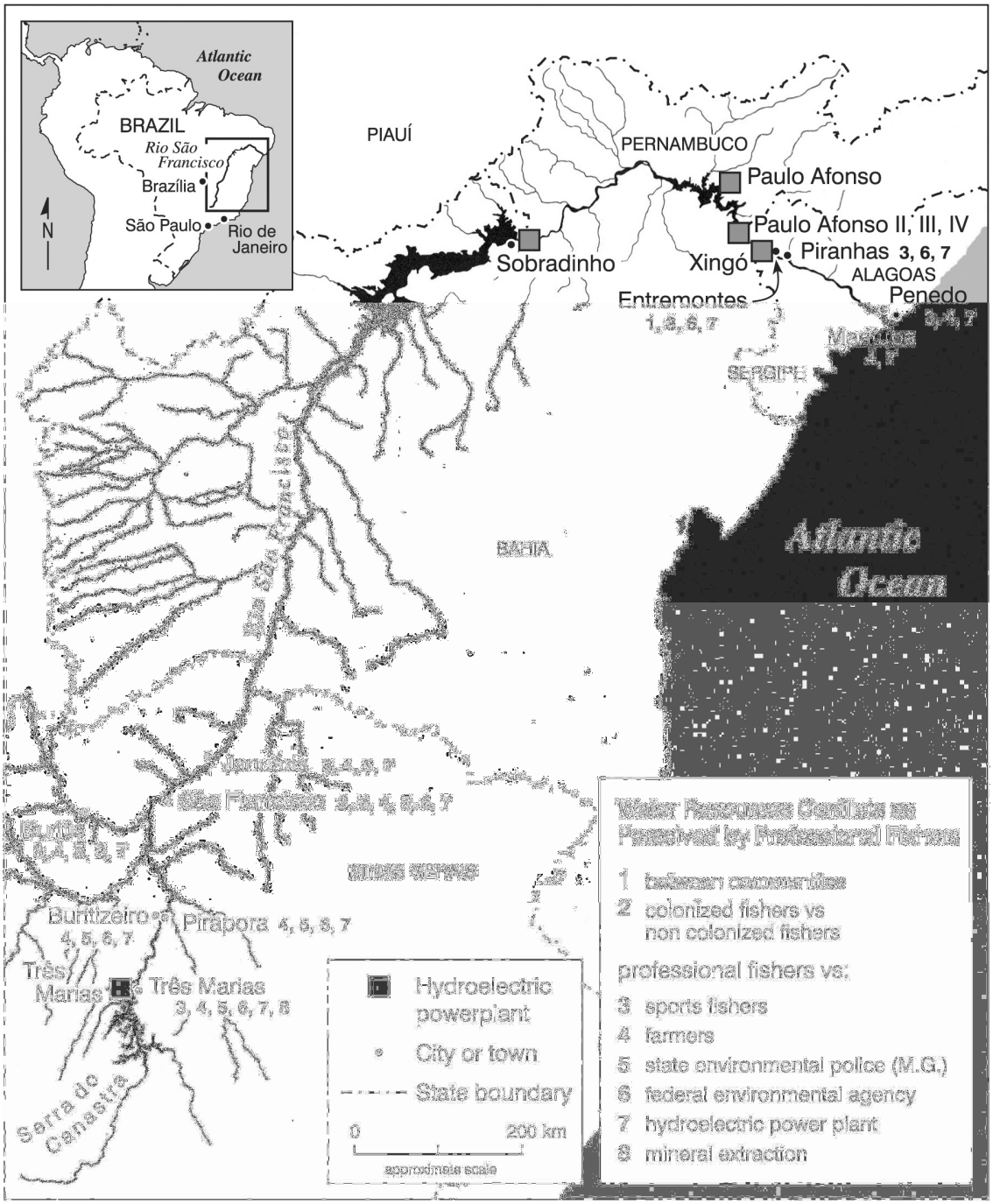
"Predatory fishery," discussed by Sato and Goldinho (n.d.,) and Thé (2003) for the São Francisco River, is a term much used socially, legally, and politically in Brazil to describe and limit illegal fisheries or practices that damage the fish stocks unduly. However, it has no clear definition and many different interpretations. Generally, it includes practices that capture individuals before they reach their sexual maturation stage and had an opportunity to reproduce at least once (e.g. undersize mesh sizes), practices that prevent at least a portion of a target group of fish from escaping for reproduction (e.g. trawl techniques ("*arrastão* and *tarrafão*) or completely closing off a river with nets), and practices that wound fish without catching them (e.g. harpoons, when not used properly). The examples most cited as problematic during the interviews conducted with fishers are the use of net mesh sizes smaller than the ones allowed by legislation and the harpoon fishery – though the harpoon fishery is also defended by many.

While the professional fishery of the São Francisco is often accused of overfishing, primarily by the sports fishing community, this assertion is vigorously denied by both the fishing community and others. Petrere et ali. (1995) conclude that the stocks are not being over-exploited in the high-mid São Francisco, based on data collected by IBAMA, CODEVASF, and themselves. Their calculation of 2,000 fishers capturing a total of 2,400 tons is small compared to the productive potential of the remaining floodplain (calculated as 3,400 – 12,000 tons/year: 200,000 ha of floodplain and a potential of 17 to 60 kg/ha/yr typical of large tropical rivers). These authors feel that the fishery stocks will only decline with further degradation of the environment or substantial growth in the fishing effort; and they emphasise the great social value of the professional fishery, and warn against undue regulation of the activity without sound technical bases.

4.2 Stakeholders conflicts

In the following section the paper presents some of the prevailing stakeholder conflicts observed in the field. Due to time constraints the conflict mapping exercise might not have captured all possible versions of stakeholder conflicts. However, it allows us to point out recurrent conflict issues. The following Figure 2 provides a summary of these conflicts and highlights where particular conflicts could be mapped during the fieldwork.

Figure 2: Water resources conflicts as perceived by professional fishers in the upper and lower São Francisco River.



4.2.1 Conflicts between fishers

There are conflicts among different fishing communities in the state of Alagoas, as a result of the construction of the Xingó hydroelectric plant. The Xingó dam has severely affected fisheries in

downstream municipalities. For that reason fishers from the municipality of Pão de Açucar began to move into fishing grounds of the neighbouring Piranhas and Entremontes municipalities.

Conflicts between professional fishers and sport/amateur fishers over access to resources and to fishing spots take place almost everywhere. Throughout Minas Gerais, for example, professional fishers using gillnets complain about sport fishers using harpoon and hook-and-line. In Alagoas conflicts arise mainly over the *surubim* harpoon fishery carried out by tourists and some local fishers, impacting on the activities of professional fishers.

There seem to be hidden conflicts between affiliated and unaffiliated fishers, based on lack of information, prejudice, misconceptions and suspicion. Unaffiliated fishers argue that the *Colônia* does not provide enough benefits for fishers and does not pay enough attention to fishers' needs. This problem was observed in all municipalities visited. Sometimes there are conflicts among different groups of professional fishers based on the use of gear that impacts the other's activity. There are also conflicts generated in some cases out of regional differences in *colônias* that cover a large geographical area: distant fishers feel less important as they cannot participate in meetings and receive news on such issues as fishing regulations with considerable delay. In some cases, this has resulted in the formation of municipal associations, such as the Ibaí Fisher Association[13], by fishers of this municipality that were members of the Colônia de Pescadores de Pirapora Z-1.

4.2.2 Conflicts involving fishers and other stakeholders

Conflicts between fishers and farmers are quite common throughout the region. The major reasons are (1) the construction of small dams in marginal lakes of the São Francisco River and its tributaries (areas used as nursery for many fish species) and (2) the construction of dams on small tributaries that prevent fish migration and spawning of some species. Farmers impede the access to riverine areas and marginal lakes, which were traditionally used by the fishers. Farmers also take water from the river to irrigate their plantations and contaminate the water with agro-toxics and cattle manure. Fishers are also aware of the indirect impacts from agriculture on the river, with deforestation of the gallery forests, erosion of the river margins and siltation.

Conflicts between fishers and the Environmental Police are present in many municipalities. Some fishers reported cases of violence and disrespectful treatment by the police. Fishers mentioned occurrences where gear and fish were caught and apprehended by the police. They also complained strongly against the high fines (minimum value of R$ 700) applied for fishing with prohibited gear or during closed fishing season, according to the regulations in place since 1998.

Conflicts between fishers and IBAMA and/or IEF agents are very common and seem to be the result of inadequate fishing regulations. Local fishers have observed that some fishing rules do not contemplate the local environmental context. Particularly with respect to the determination of the periods when fisheries are supposed to be closed, gear restrictions and limitations in species and numbers allowed to be caught. However, fishers mentioned that these conflicts have been mitigated lately due to educational programs developed by IEF.

[13] Associação de Pescadores de Ibiaí

In both states visited, fishers mentioned serious conflicts with the hydroelectric companies (CEMIG, CHESF). They identified these companies as the main responsible for changing the water regime and the water flow along the São Francisco River. Furthermore, there have been complaints over health issues in the municipalities Três Marias and Piranhas, closest to hydroelectric plants. Locals relate these disturbances to contaminants discharged into the river during maintenance of the turbines. The zinc mining company CMM[14] in the municipality of Três Marias has a track record of severe environmental impacts related to water contamination. Today the situation has improved, however, according to some fishers, residues from zinc production are still contaminating downstream water.

5. Alternative management arrangement for the São Francisco River

Co-management has been used widely for different people (government, NGOs, development agencies, researchers, users and other stakeholders) and with different meaning as a strategy to change and improve fisheries management. Co-management may be defined in several ways, but overall, it is concerned about sharing management responsibility (in several degrees) among different parties, including government, resource users and other key stakeholders (Jentoft 1989, Pinkerton 1989, Hanna 1996, McCay & Jentoft 1996, Sen & Nielsen 1996, Pomeroy & Berkes 1997, Singleton 1998, Borrini-Feyerabend et ali. 2000, Nielsen et ali. 2002). The degree of participation of each party may vary considerably.

For instance, Sen and Nielsen (1996) classified co-management in five categories according to the role of government and resource users: instructive (government informs decisions to users), consultative, cooperative, advisory, and informative (users inform decisions to government). Pomeroy and Berkes (1997, p.466) presented a hierarchy of 10 co-management arrangements "from those in which the fishers are merely consulted by the government before regulations are introduced, to those in which fishers design, implement and enforce laws and regulations with advice and assistance from the government". Nielsen et ali. (2002) subdivide co-management in two categories: instrumental and empowering. They call attention that quite often, fishing communities are involved only in the implementation process – the 'instrumental co-management' approach; while 'empowering co-management' requires involving users in defining management objectives, identifying and providing the knowledge base for management, and implementing decisions accordingly. Indeed, the degree of participation of each party may vary throughout the different phases of co-management: planning, implementation, monitoring and evaluation.

In this paper, we explore the potential of co-management as an alternative management arrangement for the São Francisco River. Understanding that co-management can take different institutional arrangements, we address in the following sub-section the major conditions and principles for effective fisheries co-management.

[14] Companhia Mineira de Metais

5.1 Principles in co-management

Pomeroy et ali. (1998) have identified 28 principles and conditions that facilitate successful implementation of fisheries co-management in Asia, but which are certainly relevant for co-management implementation in Brazil too. They are presented below, with some additional annotations:

1. *Provision of different incentives and benefits (social, economic, political) for different parties to engage in co-management.* "The co-management process often involves giving up individual short-term benefits for real and perceived long-term benefit" (Pomeroy et ali. 1998, p.6)
2. *Recognition of resources management problems by all stakeholders*.
3. *Development or existence of local leadership*. Existing community or organization leaders may not be the most appropriate leaders for co-management.
4. *Involvement of key stakeholders and establishing rapport with them.* According to Kalikoski and Satterfield (*in press*), "it is the nature of the problem that dictates the necessary parties and levels of governance to be involved". Stakeholder involvement is time consuming but is "expected to lead to more acceptable and sustainable arrangement" (Pomeroy et ali. 1998, p.8).
5. *Empowerment of individuals and communities through capacity building*. "Local people have to be empowered not just to take decisions and influence policy makers, but to implement decisions" (Brown 2002, p.11). Empowerment is particularly important to avoid that local elites take control of the process (Davis and Bailey 1996).
6. *Building trust between partners.* This requires development of good communication channels, open and on-going dialogue, and meeting mutually agreed targets.
7. *Clearly defining property-rights over resources and mechanisms to allocate user rights*. When property-rights are not clearly defined, an open-access system may emerge and 'tragedy of the commons' may occur – i.e., co-management will not be sustainable.
8. *Local political support.* This condition is no doubt very important, but there are cases of successful co-management between state/federal government and resource users with no support of local (municipal) politicians (e.g., Mamiraua Sustainable Development Reserve in Brazil, Soares, pers.comm. 2004).
9. *Capacity building for all co-management partners (government and NGO staff, researchers, users and other stakeholders) to develop or strengthen their capability for collective action, cooperation, power sharing, dialogue, leadership, and sustainable resource management.* This is particular relevant for government as co-management requires changes in government organizations and somehow disempowers them (Nielsen et ali. 2002).
10. *Existence of legitimate organizations that have a clearly defined membership*. And, adequate representation of these organizations in the co-management process (Jentoft et ali. 2001).
11. *Conflict management mechanisms*.
12. *External change agents playing a catalytic role but not interfering or influencing the process.*
13. *Clear objectives of a well-defined set of issues*. " Fundamental to co-management are a common understanding of the situation, comprehension of the root causes of the problems

and the issues, and an agreement on appropriate solutions to identified problems" (Pomeroy et ali. 1998, p. 13).

14. *Effective communication among parties*.
15. *Political and social stability*. "The partners in co-management must be unhampered by grave threats to life, property and livelihood" (Pomeroy et ali. 1998, p. 13).
16. *Networking for bringing together information and expertise, and advocacy at local and national level in support of co-management.*
17. *Enabling policies and legislations*. "The role of government in establishing conditions for co-management is the creation of legitimacy and accountability for the local organization and institutional arrangement" (Nielsen et ali. 2002, p.7). Co-management "arrangements may be undermined in the absence of legal basis… for power-sharing and decision-making." (Pomeroy et ali. 1998, p. 14).
18. *Provision of financial resources/budgets*. "Co-management must be designed from the start with a secure internal budget source. Too much dependence on external sources will impact upon sustainability of the arrangements" (Pomeroy et ali. 1998, p. 15).
19. *Effective government agency support*. Government agencies can provide assistance and services (administrative, technical and financial) to local organizations and co-management arrangements.
20. *Fit with existing and traditional social and cultural institutions and structures of the communities.*
21. *Partner sense of ownership of the co-management process.*
22. *Effective enforcement.* Enforcement may be a government or local responsibility (or a combination of both) – in any case local enforcers must be formally legitimised to carry out their activities.
23. *Partnership and contractual agreements*. Partnership is fundamental to co-management but too many organizations involved may turn coordination between partners too costly and ineffective. "It is important to have clarification about each other's role, goals, purpose, operation, style and limitations" (Pomeroy et ali. 1998, p. 17).
24. *Overlap of interest among partners*.
25. *Flexibility to cope with the unexpected and to adapt in response to new problems and opportunities.*
26. *Appropriate management scale* (area managed and people/organizations involved). Effort should be done to fit management institutions with one another and with the scale of management problems they are addressing (Folke et ali. 1997).
27. *Creation of a coordination body* with representatives from different partners to systemize the co-management arrangement – i.e., "to facilitate quick and efficient decision-making, conflict resolution, planning and cooperation". (Pomeroy et ali. 1998, p. 18).
28. *Social preparation and value formation.* "Social preparation should always precede technical and material interventions." (Pomeroy et ali. 1998, p. 18). Insufficient time allocated to social preparation may result in unsustainable arrangements.

5.2 Barriers to the implementation of fisheries co-management

In our survey we identified a number of factors that may create barriers to successful fisheries co-management. These include among other things: socio-economic exclusion of fishing communities; lack of mobilisation and low-level representation of artisanal fishers within their

own organizations and in other society's activities; patronage systems; culture of corruption and beaurocracy among some Colônias and municipal governments; stakeholder conflicts; communication problems between the different government agencies (all levels) and fishers; communication problems between and among government, NGOs and local population, including fishers; rich and more powerful stakeholders able to influence politicians' decisions; lack of infrastructure to support the processing of the fish; and lack of engagement of the municipal governments with environmental problems.

Most of these factors are comparable to Seixas' (2004) findings on challenges of implementing co-management in Brazil – a nation with a history of centralized decision-making (Table 3). The current research confirmed the following circumstances:

- Local resource users are accustomed to paternalistic and top-down decision-making. Some of the fishers seem not yet to be prepared for the challenge to engage in co-management. Much effort is still needed to mobilize, empower, and improve the representation of artisanal fishers (licensed and unlicensed fishers) within co-management arrangements.

- The extent to which policy-makers are prepared to share decision-making power and accept local knowledge as a credible knowledge system that may complement scientific knowledge varies largely. Acceptance of local knowledge seems to depend more on each individual policy-maker.

- Most initiatives lack qualified personnel to mediate the flow of knowledge and power struggles between government agencies, resource users, and other stakeholders. In order to implement co-management capacity building is necessary for all participants (government, NGO staff, including science-trained researchers and other stakeholders, in particular local fishing communities). Better community organization and empowerment of fishing communities is needed to overcome decades of socio-economic marginalization and to find a way out of the top-down and/or patron-client culture in fisheries management.

Table 3. General challenges to implementing participatory fisheries management in Brazil

Hindrances to co-management	**Occurance**[1]
Barriers to user participation	
Socio-economic and cultural marginalization of artisanal fishers	4
Culture of patron-client relations and corruption	4
Prejudice against user knowledge and literacy level by researchers and decision-makers	3
Misrepresentation of fishers within their associations and in the decision-making process	3
Physical and economic threats to those involved in assessment and enforcement	3
Existing conflicts and hierarchies	3
Government-related barriers	
Lack of government support to or recognition of co-management institutions	4
Ambivalent support from government representatives	4
User lack of trust on government agencies with a stake in co-management	4
Ineffective enforcement structure by government agencies	4
Conflicting government policies and agendas (all levels and different sectors)	3
Governance issues	
Low-level co-management: decision-making is not totally shared; government holds last word	4
Lack of a clear property rights system in the area	4
Lack of effective government presence to support and implement decisions	4
Lack of commitment and support from different stakeholders, particularly government agencies	4
Lack of capacity (funds, training, and experience) from different partners	3
Impediments to knowledge flow across scale	
Some government staff not accepting and valuing local knowledge (prejudice)	4
Lack of legal mechanisms that compel government agencies to consult fishers	3
Some government agencies not accepting user's rights for co-managing	3

[1]Cases considered: The Ceará Fisheries Reservoir Project (Christensen et ali. 1995, Barbosa & Hartmann 1997, Hartmann & Campelo 1998), the Arraial do Cabo Maritime Extractive Reserve (Lobão 2000, Silva *in press*); the Lagoa de Ibiraquera Project (NMD-UFSC 2003, Freitas *in prep*), and the Forum Lagoa dos Patos (Reis & D'Incao 2000, D'Incao & Reis 2002, Kalikoski et ali. 2002, Kalikoski & Satterfield *in press*, Kalikoski & Vasconcellos *in press*).

- All the cases examined have faced several degrees of management constraints due to the lack of support from some government agencies at different political levels and economic sectors. This often results from conflicting agenda and power disputes within or between government agencies. At the end, fisheries policy is still very much a top-down matter and so far not enough effort has been put into coordinating fisheries management with water resources management in general.

5.3 A promising resource management strategy for the Sao Francisco River and its communities

Co-management is indeed a promising alternative for resources management on the São Francisco River. Any attempt to start a co-management process should however understand the complex social, environmental, economic and political issues involved and the barriers to be overcome; but above all, it should pay attention to meet those conditions and principles for successful fisheries co-management as listed by Pomeroy et ali. (1998). This paper is a first effort to elucidate some of the issues, highlight existing assets and potential barriers for such an attempt.

Based on our findings, we suggest that any project on fisheries co-management should invest time and resources in getting a better understanding of the complex social and political settings before involving stakeholders in the negotiation process. These include lobbying government to change policies and create enabling legislation, training different stakeholders (including government) and empowering the most excluded ones, increase environmental awareness at all levels and sectors, and develop good communication channels and conflict resolution mechanisms.

One last word of caution has to be said: any initiative should be careful not to use participatory management 'slogans' and engage resource users in the process in order to legitimize pre-determined decision-making. Unfortunately, too often stakeholders are manipulated in order to achieve the goals of governments, a local elite, or more powerful stakeholders (Freitas 2004, personal communication).

6. Governance: co-management a possibility, necessity or utopia?

This paper has discussed the socio-economic and environmental scenario of traditional fishing communities of the São Francisco River. The data is the outcome of a *rapid field assessment*, interviewing resource users and other stakeholders in the region. It shows the critical situation of social and economic exclusion that fishers and their families are facing. Most of the families interviewed make less than one minimum wage on average; many practice additional subsistence agriculture and/or have their members working in day-labour contract activities to complement the household income.

To minimise poverty levels in these communities more income opportunities need to be generated, for example, by aggregating value on fish products or by creating alternative income sources. Some options are: fish farming with autochthon species (while trying to avoid any side-effects); and value-added fishery products, such as the processing of fish and fish leather. In order to provide a better and fairer income distribution, all of these activities should be managed through a joint effort such as co-operatives. Specific training in fish utilisation and processing, marketing and commercialisation, and other activities adequate for the local social-cultural context (e.g., hand-crafting, small-scale organic agriculture, boat building, tourism) could be promoted to diversify income sources in these communities.

Social exclusion of fishers can be seen through the relatively low mobilization and participation of individual fishers in decision-making and/or in efforts to guarantee their rights and to improve their well being. Many factors account for this situation, including: (1) the lack of concern of government agencies (federal, state and municipal) over artisanal fisheries issues; (2) the establishment of top-down fisheries policies, with no consultation or participation of fishers; (3) more powerful river resource users, such as farmers and hydroelectric companies, mining industries that historically have imposed their interests on public policies to the detriment of those of the fishers; and (4) the severe enforcement of fisheries regulations (considered inappropriate by many fishers) causing fishers to pay exorbitant fines or to lose their gear, which puts them into an even worse marginalized position.

In this sense, any effort towards the social inclusion of fishers and a sustainable resource management of the São Francisco River needs primarily to work with regulatory government agencies (e.g., IBAMA, IEF, municipal secretaries), so that they can start changing their attitudes and accept sharing the decision making power with resource users, including fishers. Further, it is necessary to help enforcement agencies (e.g., Environmental Police, IBAMA, IEF) to change their attitude towards fishers, so that actions become more educational instead of punishing. Integrating local and scientific knowledge is an important pre-requisite in the search of viable and sustainable solutions for socio-economic and environment problems at the São Francisco river basin.

Generally, fishers are poorly educated through the formal educational system; hence, many are illiterate. This becomes a problem in accessing information; as well, there is a lack of appropriate information routes and ways designed specifically for the fisher's needs. Fishers are in an extremely vulnerable situation and need to be empowered, in order to escape poverty. Actions towards this end includes:

- Strengthening of citizenship and self-esteem
- Informing fishers about their rights and duties
- Teaching them to write and read
- Building capacity in co-management processes

Environmental degradation and pollution was evident at all sites visited along the São Francisco River. The factors behind such impacts are complex and involve many different actors, such as farmers (cattle raising and monoculture); hydroelectric companies; industries (e.g., mining) and agribusiness. Governments' reluctance to install domestic sewage treatment is another important factor contributing to water pollution that consequently threatens fisheries and human health.

Artisanal fishers are experiencing a severe crisis, which reflects resource degradation and socio-economic exclusion. Immediate actions are required in order to recover and maintain environmental quality and to safeguard cultural diversity. Co-management can contribute in solving resource conflicts and maintaining local stewardship over the natural resources of the São Francisco River.

The CIDA-funded bilateral project "Peixes, Pessoas e Água" is currently pursuing many of the recommendations for improvement outlined in the report that originated this paper, including the

support of an affiliated IDRC-funded project (lead by the UFSCar and the Instituto Amazônico de Manejo Sustentável de Recursos Ambientais - IARA) to adapt Amazonian fisheries co-management experiences to the São Francisco fishery in the high mid-river basin. This initiative relies on recent regulatory changes in the federal fisheries agency, IBAMA, that is supportive of co-management, but also includes participatory surveys, training in leadership, building of self-esteem, and communication through community radios. New government policies, particularly of the Federal Agency for Fisheries and Aquaculture (SEAP) and CODEVASF, are planning to expand livelihood opportunities and fishery production, including participatory input and education programs to improve literacy levels for fishers. It remains to be seen what impact these initiatives will have in the future.

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Appendix I - Local Ecological Knowledge of the fishing techniques used on the São Francisco River in Minas Gerais. (Based on Thé, 2003).

TECHNIQUE	SPECIES	SEASON	LOCATION	DESCRIPTION
Caceia – drift gfill-net	Curimatá, dourado, surubim, piranha, matrinchã, pirá.	*Primarily during migration when water is turbid, but can also be used all year.*	*In the middle of the river or between the middle and the river's edge.*	"A net requiring two fishers in the boat, while one rows, the other releases the net slowly into the water with a buoy at one end until it is all stretched out across the river. It is then let drift downriver with the boat for about 1000m or until the net gets caught on a tree trunk. At this time, one fisher rows against the current, while the other collects the net, removing the fish".
Tarrafa - castnet	All fish species.	*Throughout the year, both with turbid and clear water.*	*Close to the river margins, from the shore and banks, and in the bush and shallow bays.*	"A net in the form of a sack, with a rope attached to its middle to pull it from the water and remove the fish. Used to catch bait and, with mesh sizes of 6 or 12 mm, for catching larger fish".
Pinda ou Anzol de Galho – set hooks	Surubim, dourado, piranha.	*Best in turbid water.*	*From riverbanks and margins.*	"The hook with live bait is tied to a branch with a long line. …here, the "pinda" is the "hook of the branch" … "pinda with a head" or the "caçador – hunter" is the same without being tied to a branch - …this could be with a rod stuck in the river bank and the hook in the water".
Linhada, Linha ou anzol – hook and line	Dourado, surubim, piranha	*Mostly during the clear water period, but also at any time of the year.*	*In the middle of the river or from its banks.*	"Hook and line, used in the hand, with the boat stopped in the middle of the river or on the river bank, without a specific location … bait can be anything – a worm or a mandi catfish, secured until a fish bites".
Terreina	Dourado, piranha, surubim, mandim	*Any time of the year, but mostly during clear water period when the river is low.*	*Anywhere in the river, but mostly in the middle.*	"Live bait, white mandi catfish, or spiny mandi, a hook and a hand-line … the line is jigged to make the bait fish make sounds – with each jig the fish screams and the dourado comes to the sound. If the mandi stops singing it needs to be changed. It is done with the boat drifting downstream and the motor turned off".
Aço – steel	Dourado, piranha, matrinchã, mandim, gongo.	*During migration with turbid water.*	*From the middle of the river to the margin, in shallow areas or areas with rocks and shallow bays.*	"Steel hooks held together by wire. Used in the middle of the river … used from November to February, or all year for those that don't use nets".
Grozeira	Mandim (gongó), surubim, piranha, matrinchã.	*All year, any season.*	*Both from the margin and in the middle, mostly in deep areas.*	"A line full of hooks below the water – with a buoy and tied to a rock on the bottom … for catching mandi, matrinchã, dourado and piranha".
Currico	Dourado	*In clear water.*	*In the middle of the river, from the shore, or any location.*	"Spoon with about 20 metres of nylon line – pulled along the surface of the water with the spoon spinning and shining – similar to artificial bait, only works with the boat moving".

Rodada	Dourado, Piranha.	*In clear water.*	*In the middle of the river, but also in any other locations.* .	"Similar to the "terreina" but with a different bait such as piau, sarapó, matrinchã…arriving at a location by boat, the motor is turned off … the hook with bait is thrown over and jigged with the boat drifting downstream … this is different from the terreina because it is a different bait …the piau does not scream, but also catches the dourado". (Três Marias)
Arpão, Fisga – harpoon and gaff hook (Três Marias)	Dourado, surubim, curimata.	*Clear water.*	*Margin, shallow water, any areas.*	"A shaft with a triple hook embedded in the tip and a hole for a buoy line in the handle – the speared fish tries to run away towing the line and buoy … used together with a night-light".
Tarrafão	Surubim, dourado, any fish.	*In turbid water.*	*In any location, mid-river and along the edge, in rapids, falls, and springs.*	"A castnet with a double mesh that is trawled along the bottom".