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THE LONG JOURNEY TO BECOME THE 'RIVER OF NATIONAL UNITY': THE SÃO FRANCISCO RIVER BASIN FROM 1940S TO 2008 AND THE INTERACTIONS OF ENVIRONMENT, GOVERNMENT AND LOCAL CITIZENS.

BY

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DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy
in
Natural Resources and Environmental Studies

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DEDICATION

To Mainha and Marc,
Lu, Syl and Deu

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ACRONYMS AND GLOSSARY

	English	Portuguese
ANA	National Water Agency	*Agência Nacional de Águas*
CBHSF	São Francisco River Basin Committee	*Comitê da Bacia Hidrográfica do Rio São Francisco*
CEMIG	Minas Gerais State Hydropower Company	*Centrais Elétricas de Minas Gerais*
CHESF	São Francisco Hydro Power Company	*Companhia Hidro Elétrica do São Francisco*
CNRH	National Water Resources Council or National Water Council	*Conselho Nacional de Recursos Hídricos*
CODEVASF	São Francisco and Parnaíba Valleys Development Company	*Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba*
CVSF	São Francisco Valley Commission	*Comissão do Vale do São Francisco*
DNOCS	National Department for Works Against Droughts	*Departamento Nacional de Obras Contra as Secas*
EA	Ecosystem approach Ecosystem-based management	-
Outorga	Permit to use the water	*Direito de uso*
PSAF	Policy Sciences Analytic Framework	-
Revitalization	São Francisco River Revitalization Program	*Programa de Revitalização do Rio São Francisco*
SFR	São Francisco River	*Rio São Francisco*
São Francisco River	River of National Unity National Unity River National Integration River Old Francisco	*Rio da Unidade Nacional* *Rio da Integração Nacional* *Velho Chico*
SFRB	São Francisco River Basin	*Bacia Hidrográfica do Rio São Francisco*
SUDENE	Superintendence for the Development of the Northeast	*Superintendência do Desenvolvimento do Nordeste*
SUVALE	São Francisco Valley Superintendence	*Superintendência do Vale do São Francisco*
Transposição	Inter-basin Water Transfer Project	*Projeto de Interligação de Bacias do Rio São Francisco*

ABSTRACT

THE LONG JOURNEY TO BECOME THE 'RIVER OF NATIONAL UNITY':

THE *SÃO FRANCISCO* RIVER BASIN FROM 1940S TO 2008 AND

THE INTERACTIONS OF ENVIRONMENT, GOVERNMENT AND LOCAL CITIZENS.

by

Lucigleide Nery Nascimento

University of New Hampshire, December, 2010

In its 2,700 kilometers north and then eastern journey to the Atlantic Ocean, the *São Francisco* River of Brazil drains eight percent of the nation's territory. The watershed is three and a half times the size of New England. This research investigates the impacts of the federal water resource management, or lack of it, on the riverine environment and on the life of the people who locally have depended on the ecosystem's services of the river during the 1940s-2008 timeframe. A new legal instrument, the 1997 Water Policy, introduced a novel form of management regarding public participation, policy goals and ways of achieving them. The new policy mandates participation of multiple stakeholders' groups in the governance of the water resources of Brazil bounded by natural over political jurisdictions. Nevertheless, the participation of the *São Francisco* River Basin Committee in the final outcomes of the management of the water body is still limited. This doctoral dissertation applied the Policy Sciences Analytic Framework, a tool for policy investigations, to map the problem and the decision and social processes. Ecological Sustainability and Ecosystem Approach are the theoretical components and criteria of analysis. This multi-method study is based upon qualitative field-based empirical and library research, a critical assessment of secondary literature, interviews and field observations. In the *São Francisco* River Basin, environmental and social costs have risen as development increased. The uses of the river have shifted from the local in the pre-1950s to the regional and international in the post-1950s era. The intensive employment of the water body for entrepreneurial purposes like hydro-businesses is rising. The 1997 Water Policy has not yet reversed the unsustainable ecological trend of the river system, which shows various indicators of stress. This dissertation written as a case study presents results based upon seven municipalities of the basin (*Pirapora, Bom Jesus da Lapa, Juazeiro, Petrolina, Penedo, Santana do São Francisco* and *Brejo Grande*).

CHAPTER I

INTRODUCTION

The *São Francisco* River (SFR) arises in *Serra da Canastra* mountain range, in the southeastern region of Brazil, in *Minas Gerais* (MG) state. In its 2,700 kilometers north and then eastern journey to the Atlantic Ocean, the river drains eight percent of the nation's territory, an area of the size of Spain, Portugal and Denmark, mostly in *Savannah* and *Steppe* biomes. MG contributes with about three-fourths of the water body's flow (MMA 2006a). Some fifty-seven percent of the basin is located in a drought prone semi-arid climatic zone (CBHSF 2004).

The river has long been a source of spiritual, cultural, ecological, and material strengths for the people living along it and the ones who migrate out seeking livelihood in other parts of Brazil. The SFR is, according to a religious figure, "the father and mother of the locals... they request blessings... clean their face... the stream is the big god's gift for these people" (Religious figure, PC, 13 Jan 2007, *Barra*-BA).[1] In 2002, during my first reconnaissance trip into the valley, I heard from a seller in a local popular market in *Paulo Afonso* city, a statement that captures the importance of that watercourse: "following the river is richness". Throughout my several trips, I came across versions of that sentence repeated by residents in all cities I visited regarding the river's importance and the locals' dependence on it. A clothes washer summarized its importance saying: "if the *São Francisco* River dies, it will be the end of us all;" and "there is no life without the *São*

[1] PC means Personal Communication.

Francisco" (Clothes washer#1, PC, 01 Aug 2006, *Juazeiro*-BA; Clothes washer#2, PC, 16 May 2007, *Pirapora*-MG).

In 2001, the President of Brazil, Fernando Henrique Cardoso, created by decree the *São Francisco* River Basin Committee (CBHSF). The new institution introduced watershed-based management to an area of about 640,000 sq km drained by the water body Brazilians know as the River of National Unity and its tributaries.[2] Prior to the existence of the CBHSF, the *São Francisco* Valley Commission (CVSF) and subsequent federal institutions, *São Francisco* Valley Superintendence (SUVALE) and *São Francisco* Valley Development Company (CODEVASF), had used the watershed's boundaries to delineate their area of governance. Nevertheless, in practice, until the implementation of the CBHSF's watershed-based management and other tools mandated by the 1997 National Water Policy [#9,433 of 1997], a holistic approach centered on policy and practice to sustain water courses and their natural resources had never taken place, and transformed the basin into a unity of environmental management. Instead, for example projects to generate hydropower in the valley, which supported the development of the Northeast, led to negative environmental consequences the local inhabitants see daily while standing on the banks of the *Velho Chico*.[3] The basin has been a source of resources for other regions of Brazil and of the world, but also a place where negative externalities from activities elsewhere are experienced.

Historically, in practice, members of the Brazilian government have paid little attention to the health and integrity of the *National Unity* River. What has changed? How does the new differ from old forms of governance of this riverine system? The 1997 Water Policy introduced a more ecological approach to water resources management. But, the monetary resources applied to the implementation of the *São Francisco* River

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[2] Euclides da Cunha, an important Brazilian writer, in his book *Os Sertões*, described the *São Francisco* River as the "ethnical unifier" because the water body linked men and societies from the north and south of Brazil. Cunha published the first edition of this book in 1902 (Cunha 1902, 2005).
[3] *Velho Chico*, meaning *Old Francisco*, is another *São Francisco* River's affectionate nickname.

Revitalization Program compared to the sum to build an inter-basin water transfer project, and the existence of this project per se, reveal that the federal government is still not committed to the river's sustainability and restoration.

What have been the consequences of the federal water resource management or lack of it, on the waterway's environment and on the life of the ones who depend on it? Colonial occupation, deforestation, urbanization, lack of sewage treatment plants, irrigation practices, mining and industrial activities, and the existence of hydropower infrastructures represent past and current origins of environmental problems. Erosion of the river's banks, siltation, water pollution and degradation of fishing are some of the effects that threaten the sustainability of the river and its populations. Negative environmental issues reflect the absence of and the mismanagement of the human uses of the *São Francisco* River resources by the federal government during a period of time when 'environmental sustainability' was simply not on the radar. How about today, will the Water Policy [# 9,433 of 1997] achieve its proposed aims? In Brazil, laws follow two courses: implemented and enforced ("*que pega*"); and forgotten ("*não pega*"). Which course will be the path of policy 9,433 of 1997?

Objective and Methodology

This doctoral dissertation applied the Policy Sciences Analytic Framework (PSAF) to guide the understanding of the environmental history and to assess the case of the *São Francisco* River Basin (SFRB) (Lasswell 1971, Clark 2002). This research used the PSAF to orient the problem of environmental issues of the *Old Francisco*, inserted on its manifold correlated contexts, such as ecological, social, and economic. This study investigated past forms of management of the SFR's resources. This project evaluated the 'new' prescription [Water Policy # 9,433 of 1997] and the oversight and contribution to the

implementation of its instruments for this watershed focusing on the work of the CBHSF.[4] In addition, the research contrasted the Ecosystem Approach (EA) against observed data, content of interviews, and existing literature on the SFRB to assess the system's sustainability and to evaluate the similarities between EA and the new model of river basin governance (Pirot *et al.* 2000, Becker 1996).

The general objective of this multidisciplinary research was to compile and analyze relevant data, which then formed the basis to provide recommendations for the sustainable use of the *São Francisco* River water resources by present and future generations. PSAF is the organizational map of investigation. The conceptual framework derived from the ecosystem approach and sustainability theory.

The specific objectives of this project are:

- To learn how the *São Francisco* River Basin ecosystem has evolved to the present stage of stress and what the current level of stress is. To uncover the revealed policy and institutional arrangements and water resource management practices that led the SFR Basin ecosystem to the current state of stress.
- To gain knowledge about the new policies and institutional arrangements focusing on ecosystem-based management. To learn how the new approaches differ from past ones and how they compare to other approaches of ecosystem-based management of human activities used to restore ecosystem health. Finally to assess the extent to which the new approaches could enable a sustainable management plan to succeed, and if not, what would need to be changed and how.
- To uncover the roles citizens have been playing in the governance of the water resources of SFR and how the new approach of management might foster a

[4] The 'new' policy is already twelve-year old.

more effective participation and collaboration among diverse users of the system's resources to achieve sustainability goals.

In addition, this study dealt with an unstated objective, environmental justice:

- To assess the concentration of power in the management of the waters of the *São Francisco* River. To learn what segments have born the burdens and what sectors have accumulated the benefits.

Research Questions

The major question of this study is **what have been the impacts of the federal water resource management, or lack of it, on the riverine environment and on the life of the people who locally depended on river's services from the 1940s to 2008?** To address this question I also needed to learn **how does the new approach to water resources governance, endorsed by the Water Policy # 9,433 of January 08, 1997, promoted in the *São Francisco* River Basin by its respective watershed-based management committee, the *São Francisco River Basin Committee* (CBHSF), differ from old forms of governance regarding public participation and the achievement of its intended goals, such as sustainability, and to what extent is it succeeding?**

Importance

The Importance of the Basin

This river has played an important role in Brazilian history due to its location. It linked the north and the south of Brazil in a period of time when water navigation was the most important form of transportation. Today, the basin is home for almost 8% of Brazil's population and occupies 8% of the nation's territory. It supplies environmental services, such as electricity and agricultural products, not only for the valley's inhabitants, but also to other parts of Brazil and even the world. In addition, the place exemplifies the disparity

between the regional situation and the aggregate number and view that Brazil is a water rich environment (Gleick 2009). Repeated longer lasting droughts affect the semi-arid region of the basin and it is the context for water use conflicts, which have even resulted in deaths and a much-publicized hunger-strike. The river is also important culturally. Brazilians sing and pray for the *São Francisco*. The basin is the context for literary novels, movies, and for religious celebrations, such as the *Bom Jesus da Lapa* Pilgrimage and *Bye Bye Brazil* movie.

The Importance of this Study

A gap exists in relation to economic, social, and especially ecological information from the period prior to the construction of the hydropower generation facilities and infrastructure to 2000. I could not identify any study, which looks at the role of citizens, government and public policy on the management of the SFR system, and in particular its consequences for humans and environment, and which assesses trends regarding the health and integrity of the SFR environment from 1940 to now. Nevertheless, recent information has emerged about the ecological condition of the river, especially because of the creation of the *São Francisco* River Basin Committee and the controversial issue regarding the transfer of water from the SFR to other basins (*Transposição*). Thus this study has established the context for understanding the present by tracking the environmental history of the river and its management for the last sixty years.

The Rationale and Structure

The public management or lack of such during 1940s-1997 of the river's resources has affected people's uses and the overall environment. This study uncovers how those transformations have impacted the way of life and local people's values and uses of the river. It reports on the importance of and documents traditional and scientific knowledge

of this ecosystem. It blends these two forms of expertise towards an understanding of this Brazilian model of natural resources governance and human-river environment relationship. Many authors have recognized that mixture as the key to achieve the "ultimate ends" of sustainability (Meadows 1998, Singh and Titi 1995, Berkes *et al.* 2000). This study reports on the opinions of the local people about what ecological, economic and social changes past and present management systems have created. Finally it reports their proposed solutions to address existing and future problems.

The Contribution of this Study

This research adds to the literature on new policies and institutional arrangements for ecosystem-based management and on citizens' and government's roles in the administration of natural resources in a developing country. The study provides a unique multidisciplinary (ecological, social, economic, and historic) investigation of the relationship between human beings and a river environment.[5] This research assesses the ability of the existing 'new' tools to solve problems. It identifies points where interventions could create the necessary changes to foster more sustainable uses of the system. It points out lessons learned that could be helpful for the management of the SFRB and of other basin systems in the future. This research also provides an opportunity to discuss sustainability in a concrete case.

Delimitations and Limitations

Temporal Boundaries

In 1913, the first hydroelectric station, a private entrepreneurship, *Usina Hidrelétrica Angiquinho* or *Delmiro Gouveia* started functioning near the *Paulo Afonso*

[5] This is a topic of enormous contemporary significance, for example, the United Nations Development Programme's *Human Development Report 2006* is devoted to "Beyond Scarcity: Power, Poverty and the Global Water Crisis."

Waterfall (Figure 1.1 below). The activity was of a small-scale nature. The River of National Unity kept following its major course and maintained its natural level. This result was very different from subsequent interventions. The construction of larger dams and electricity generation plants prompted vast environmental and socio-economic changes (CVSF 1959, Collins and Krippner 1999, Hall 1994, CBHSF 2004).

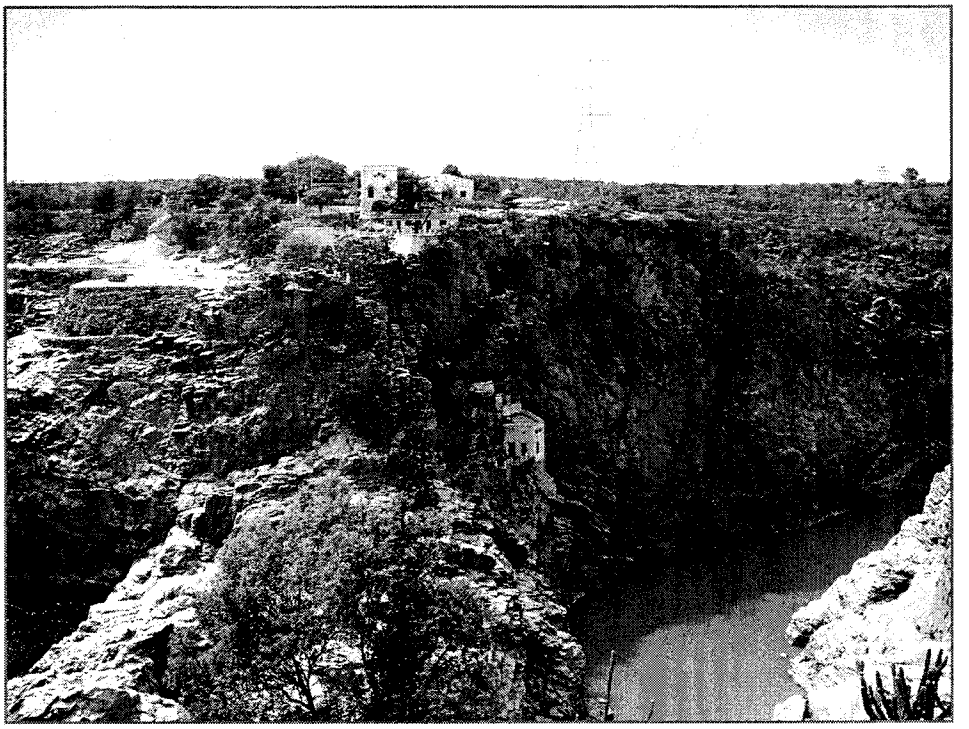

Figure 1.1. *Delmiro Gouveia* Hydropower Station
Source: Lucigleide Nascimento 2002

The electric sector has become the major water user in the valley, and positioned itself as a planner and regulator of the hydro resources of the basin. Nine dams and the human management of them govern the flow of the *São Francisco*. The timeframe covered in this project is the period between 1940s and 2008. It comprises the years immediately before, during, and after-construction of large-scale government owned and operated hydropower plants and the infrastructure necessary to make them functional. The 1940s precedes major developmental plans for the basin. It is important to

know what the environment was before these transformations and understand what its current status is.

Spatial Boundaries

The natural borders of the *São Francisco* Basin bounds the region of study. This research focused its attention on its major water course, constrained by the lack of resources (e.g., time, funding) to investigate its 168 tributaries. The choice was also based upon the knowledge that, a river reflects what happens in its watershed drainage zone. Due to the different realities of the populations living along the river, this research used seven municipalities (*Pirapora, Bom Jesus da Lapa, Juazeiro, Petrolina, Penedo, Santana do São Francisco* and *Brejo Grande*), distributed in the four distinct physiographic areas of the watershed, to get a closer view of the history, problems, and environmental issues locals have faced. It has been a long journey for the water body known as the "River of National Unity" to be seen as a "unity" of management seeking to sustain river and watershed resources based upon a more ecological approach.

Observational Standpoint

This section is important to make the reader aware of and to remind myself to not let my own bias compromise the objectivity of this research. This section describes the researcher's preconceptions, base values and other variables that might influence my views. My understanding of the world and its systems, such as environmental, social, and economic as well as how human and natural systems interact, initially arises from the experience of living in a South American country. My experience and heritage as a Brazilian citizen, born and raised in a developing country, and having lived there until coming to the United States ten years ago, has given me a different perspective in the way I see the *São Francisco* River ecosystem and its elements.

A very devoted Catholic mother of a poor female-headed family raised my sister and me with close ties to relatives, neighbors, and friends who comprised our extended family. Since I was a child, I have been hearing from different media sources, such as television and radio, about the environmental situation of the *São Francisco* River basin and the social condition of its inhabitants. Nonetheless, what struck me the most as a child was that the majority of news portrayed the difficulty of living in such a harsh environment, with seasonal drought in a semi-arid climatic zone. It was difficult to understand why people did not just leave such a place, why the government did not solve the problem, and why the situation could be so difficult if the *São Francisco* River is a permanent source of water.

However, as an adult, with an undergraduate degree on Economics from *Universidade Católica do Salvador*, earned in January of 1999, a Masters degree in Natural Resources: Environmental Conservation from the University of New Hampshire – UNH received in December of 2003, and as a Ph.D. candidate in the Natural Resources and Earth Systems Science program also at UNH, I understood that the problem and its solutions, were not as simple as a child could dare imagine. International and national contexts and variables can make the 'local' matter very complicated.

Brazil is the motherland of inequality, ranked just behind a few countries in the world under the United Nations Development Program's classification of inequality in income or expenditure (Watkins 2006). The ownership of resources and access to them are heavily concentrated in the hands of a few, as is power and the interests which govern the country. Brazilian society still struggles with other negative issues, such as gender and racial gaps, which are more serious in some areas of the nation than in others. The country is a Federal Republic with a governance system modeled after that of United States, but with a very different history. After twenty-one years of military dictatorship, Brazil has, since 1985, had direct elections. The majority of the population

participates in the 'democratic' process of choosing political representatives, even though the participation of citizens in the election (vote) process is mandatory. Many Brazilians focus on the short-term issues, as they are too busy trying to survive the everyday struggle of life. Many Brazilians do not recognize the importance of electing the country's leaders and the accountability that they must have for building a better society. In 2009, Brazil ranked number seventy-five by a nongovernmental organization, Transparency International's list of 180 countries where corruption in the public sector is perceived by residents and non-residents experts (Transparency International 2010). In the same way, many do not perceive the further necessity and responsibility of pushing and assuring that the politicians are going in the right direction: to walk a path toward a fair society for people and general environment (Ghanem 1998, Abers and Keck 2009).

Brazil has a society where citizens, mainly poor, discover early in life that they have to take care of themselves. They learn that should not count on the government to help, and this has led to my interest in the power of citizens to trigger and lead changes. Stakeholders should play a role in the management and towards the sustainability of the *São Francisco* River. It is also important to know what role public participation has played and if it has changed over time.

I paid attention to my own biases. My life experience and struggle to be part of a segment of the society where the majority of its population believes that I do not belong, because I am a black woman from a lower social class family, can lead me to overemphasize the need and importance of citizen participation over the worth of legal and institutional frameworks, such as laws and governmental entities. I also have a predisposition toward idealizing the past.

As a researcher, specifically a participant observer, I sought enlightenment, skill, well-being, respect and rectitude (Clark 2002).[6] I understood that, my presence probably affected the other's behavior. I wanted to learn about the environmental, social, and economic history of the area under investigation; be able to put into practice some of my knowledge; be able to have recognition of my work independently of my race, gender, and social class; and be a model for ethical behavior. I also created new situations for participation of the interviewees, such as in a group interview with a fishermen's association and individual interviews at work places and in interviewees' home.

My goal was to provide recommendations for average Brazilian individuals as well as decision-makers on the importance of holistic approaches toward sustainability in the management of human use of natural resources. I wanted to reveal lessons learned from past management of the river and its resources and on the need for the focus on the health and integrity of the *São Francisco* River system. I also sought to show the significance of the engagement and participation of the different players, such as citizens, government, and laws.

The greater knowledge gained from this study was learning about a reality that I did not know much about, the resistance of social movements. Yes, they do exist, mobilize themselves and undertake hunger strikes. They walk together in demonstrations on Brazil's streets and so on. Nevertheless, a difference exists; they can count on an ally now. The Brazilian Water Policy [#9,433 of 1997] mandates via watershed-based committees an institutionalized form of public participation. But, not all embrace this new opportunity of engagement. They still employ popular models of social movements.

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[6] "The participant observer engages in activities which are part of the ordinary life-pattern of his [hers] subjects" (Lasswell 1939, 378).

Overview of Methods and Subsequent Chapters

This multi-method study was based upon qualitative field-based empirical research, including a critical assessment of secondary literature. It used multiple sources of primary and secondary data. I undertook this research in four phases: scope, data specification and collection, data analysis, and presentation of results. Phase I consisted of visits to the valley before field work to increase my understanding of the reality of people's lives and of the general environment. I also sought to identify sources of information including key informants and libraries. During Phase II I clarified and specified the rules to apply during data collection and analysis, improving the research protocol I had drafted and presented during my proposal and Doctoral exam defenses. I then undertook field work which consisted of visits to libraries, observations, and interviews. Phase III, data analysis, has taken place together with data collection. Phase IV presents the results of this long journey. This research was reported as a case study (Yin 1994) and contains, besides this introductory section, the following chapters:

The Chapter II. Problem Orientation I: The *São Francisco* River System utilized literature review, field observations and interviews to describe the system, document environmental changes, and anthropogenic (e.g., dams, urbanization, and land use/change) and natural driving forces (e.g., droughts) that have transformed the local ecosystems and the human uses of them. The Chapter III. Methodology presented the organizational framework applied to this research. It also introduced the theoretical propositions as foundations against which the collected and aggregated data have been contrasted during the course of this investigation.

The Chapter IV. Water Resources Governance described the major institutions, meaning the legal and institutional frameworks, which have governed the uses of the water of the *São Francisco*. It was based upon the review of the literature, interviews and field observations. The Chapter V. The Role of Public Participation employed those same

methods to assess the role of the public in the management of the resources of the *Velho Chico*.

The Chapter VI. Problem Orientation II: A Closer View of Seven Municipalities of the Basin – Their Transformed Environment and Socio-Economic Contexts applied field observations, literature review, and interviews to describe preliminary findings. This chapter provided a closer view of the changes that have been taking place in the river environment and societies that inhabits those riparian municipalities.

The Chapter VII. Evaluation: Findings and Discussion contrasted the conceptual framework described in Chapter III with the data of Chapters II, IV, V, and VI to provide an analysis of the three components of this river system and research: natural environment, government and local people. It showed how the federal government has stood between the river environment and the local residents possibilities of achieving their means of livelihoods.

The Chapter VIII. Conclusions and Recommendations contains the final comments derived from this research. It presents the successes and failures of the 1997 Water Policy from the perspective of a policy scientist. It identifies places to intervene in the system (leverage points) and provides general recommendations. This chapter points out the lessons learned from the study of this case and the research task in general. Because natural and human systems are evolving, this chapter also projects future trends that will likely take place and affect the river and water resources of the basin. This research "temporarily" ends here, but before doing so, it suggests future and further studies. The journey never ends.

CHAPTER II

PROBLEM ORIENTATION I: THE *SÃO FRANCISCO* RIVER SYSTEM

"Problem orientation" is one dimension of the Policy Sciences Analytic Framework methodology (Clark 2002). It aids understanding an issue of concern and is necessary to create a policy solution compatible with the problem it is attempting to address (Lasswell 1971). This chapter describes the *São Francisco* River Basin system: its geography, its history and its major uses. The chapter is based upon the triangulation of information acquired from the review of existing studies, from my own observations and assessments of the river and surrounding environment, and, last but not less importantly, relies upon details from interviews of local residents and outside experts.

Historic Perspectives

European explorers "discovered" the mouth of the *São Francisco* in October 4 of the year 1501 (Rocha 1983). Two main human currents conquered the valley.[1] Initially, the first took place with small settlements in the end of the sixteenth century. *Garcia D'Ávila* entered the *São Francisco* Valley in the lower to upper-SFR direction and left posts along his way: a pair of slaves, cattle and horses (Rocha 1983). The second wave of exploration began in the opposite direction with explorers, the *Bandeirantes,* seeking gold and precious stones in the late seventeenth century (IBGE 1960). They also established cattle farms (Crist 1944).

[1] Researches cite additional waves of occupation, such as Matias Cardoso's expedition to pacify a native indigenous tribe, the *Cariris*, located in the middle-SFR valley, at the end of the seventeenth century (IBGE 1960).

Indigenous native people, white Europeans, as well as Africans slaves and escapees comprised the inhabitants of the basin during Brazilian colonial times (CODEVASF 1978). Cattle raising activities led to the expansion of the human population throughout the area. Given the rivers' function in relation to livestock, it became the *Corral's* River (*Rio dos Currais*) (Diégues Jr. 1971, CODEVASF 1978).[2] The local economy of the basin included fishing; agricultural activities producing beans, rice, corn, fruits, cassava flour, tobacco, and sugar-cane on a small scale; and exploiting other natural resources, the *pau-brasil* or Brazilwood (*Caesalpinia echinata*) for export (Diégues Jr. 1971). The products of the SFR basin supplied local and regional markets, such as the coastal zones of *Bahia* and *Pernambuco* and later on included mining areas of *Minas Gerais* (Rocha 1983, Diégues Jr. 1971, Cerqueira 1988). Salt was an important merchandise item, as well as having been used in cattle raising and fish salting (Diégues Jr. 1971, CODEVASF 1978, Sampaio 2002). During colonial times, the *São Francisco* served two major purposes for the nation: (1) its resources allowed population settlement in the basin, and the (2) stream and tributaries linked inland regions (Rocha 1983).

The Geography of the Watershed

The *São Francisco* River

The SFR arises in *Serra da Canastra* mountain range, in the southern part of the state of *Minas Gerais* (Pierson 1972, vol.1).[3] The river heads north and then takes an eastern journey for a total of about 2,700 kilometers, finally flowing into the Atlantic Ocean (Figure 2.1 below). The people, who have seen the river humbly springing up as a

[2] The rancher culture has subsisted until today in the basin. Cassava flour and salted meat have been the two most important ingredients of the basic diet package of inland populations of the valley outside of its riparian borders (Rocha 1983). Leather is still the base for several traditional regional accessories, such as hats, and shoes.

[3] In 1972, the federal government created a national park in the area where the river raises, the *Parque Nacional da Serra da Canastra* (Peçanha 1974). Researchers have identified the *Samburá River* as the new beginning of the *São Francisco* (CODEVASF staff, interview, 24 Apr 2007, Brasília-DF).

narrow inlet from its source, cannot believe the magnitude the waterway takes along its stretch. An interviewee questioned: "how that little brook can become this [watercourse]?" (Public employee-CBHSF, PC, 17 May 2007, *Pirapora*-MG).[4]

Figure 2.1. The *São Francisco* River (blue line)
Source: derived from georeferenced data available from http://siscom.ibama.gov.br/shapes visited on October 10, 2009 (IBAMA 2009).

The waterway crosses the Brazilian *Central Plateau*. It has significant waterfalls. Its first important one, *Casca d'Anta* is in *Minas Gerais*, and is 180 meters high (Pierson 1972, vol. 1). Nevertheless, *Paulo Afonso* is "the queen of falls" (Burton 1977; 1869, 39). It is eighty-one meters high (Azevedo 1968, vol. 1). It is located in the division between the

[4] PC means Personal Communication

lower-middle and the lower-SFR, and it has delighted many of its visitors, as stated in the paragraph below.

> The main water-fall forms a curved line; the stony channel that the stream passes through impels it north-ward, on its half way, against the opposite waters, the two currents being mingled together and as it were crushing each other. From this point water can no longer be recognized as a distinguishable mass; it is all over–foam, vapor, fog, and then, with an immense leap, the disordered chaos of the broken waters precipitates into the abyss. (Vianna 1893, 27-28)

A lengthy, and what used to be a navigable zone, extends from *Pirapora* to *Juazeiro* (BA)-*Petrolina* (PE) for 1,371 kms. The second sailable stretch is 208 kms long (SUDENE 1980). It is located between *Piranhas* (AL) and the *Velho Chico*'s mouth (AL/SE). The *Velho Chico* has numerous fluvial islands along its course. The natural average discharge in the lower-SFR is of 2,850 m^3/s.[5] But a hydropower corporation maintains the average flow level of 1,815 m^3/s. The ten-year management plan for the basin established a minimal daily average discharge volume of 1,300 m^3/s, though at times flow rates above this need occur. Three aquifer domains exist in the basin. The most important form, porous aquifers, occupies 43% of the watershed area, accounting for 88% of the groundwater available, some 287 m^3/s from the 318 m^3/s of the figure of the basin. Part of this resource contributes to the discharge of the *Velho Chico* mentioned above. Groundwater is used for several purposes in the watershed, including public water supply and irrigation (CBHSF 2004).

The Tributaries

Ninety-nine permanent and sixty-nine intermittent water bodies flow into the National Unity River (*Rio da Unidade Nacional*).[6] The east and west banks' tributaries

[5] It is the average discharge for the period between 1931 and 2001 (CBHSF 2004). Some 73.5% of the SFR's flow (natural average discharge) comes from the upper-SFR in *Minas Gerais* (MMA 2006a).

[6] Several rivers in the Northeast only exist during the raining season. During the dry season, if they exist, they can be easily crossed, receiving the name of "interrupted rivers" ("*rios cortados*") (IBGE 1960b: 207).

contribute in different ways.[7] In general, streams on the west margin result from direct precipitation and from the natural reservoirs of the biome *Cerrado* (Savanna), mostly under the effect of a hot and humid climate.[8] Rivers on the east side manifest a semi-arid climate and the biome *Caatinga* (steppe).[9] In this case, nearly all watercourses are intermittent, and determined by the precipitation from the wet time of the year. The *São Francisco* River's flow receives small contributions from most of these east bank tributaries due to their intermittence.

Table 2.1. Major Tributaries

River	Bank (looking downstream)	Percentage of Contribution to the SFR's Average Discharge (2,850 m^3/s)[10]
Paraopeba	East	6%
Rio das Velhas	East	13%
Paracatu	West	14%
Urucuia	West	9%
Carinhanha	West	6%
Corrente	West	7%
Grande	West	9%

Source of data: CBHSF 2004, 70.

According to a major literary writer, Guimarães Rosa, in the backlands of the Northeast, the *Sertão*, the "*São Francisco* is the only river, Chico's River", the "capital river" (Rosa 1983, 55, 220).[11] It is hydrologically and socially important. It is one, among

[7] Geographical position based upon one standing with his/hers back to the river's source in Minas Gerais.
[8] *Cerrado* extends over about 21% of the country's land area, predominantly in the central zone of the nation (MMA 2007). Temperatures range from 71.6° to 80.6° F and the annual rainfall is on average 1,500 mm (Klink and Machado 2005). The *Cerrado* is rich in biodiversity (MMA 2007, Klink and Machado 2005). Cerrado porous soils allows aquifers formation(IBGE 1960b).
[9] *Caatinga* occupies about 734,478 sq. km, 11% of the national territory, mostly of the Brazilian Northeast. A long dry season, irregularity and low volume of rainfall (400-600 mm), and the existence of intermittent and seasonal rivers characterize this biome (MMA 2007).
[10] The total does not add to a 100% since the SFR has other tributaries.
[11] *Sertão* means the semi-arid interior of Northeast (Robock 1963). Bernardes (1999) suggests that the term *Sertão* was initially used to describe non-developed/exploited zones. Nonetheless, it now means area covered by *Caatinga* vegetation. Its inhabitants use the word to describe lands with low density and productivity (Bernardes 1999). The annual average precipitation in the *Sertão* is between 500 and 750 ml (Katzman 1977).

few permanent sources of water for many. But, it receives the contribution of other continuous water bodies. Among the thirty-six major SFR's tributaries, only nineteen of them are permanent water bodies (CODEVASF 1989). The Table 2.1 above lists and the Figure 2.2 below shows the geographical location of its significant tributaries.

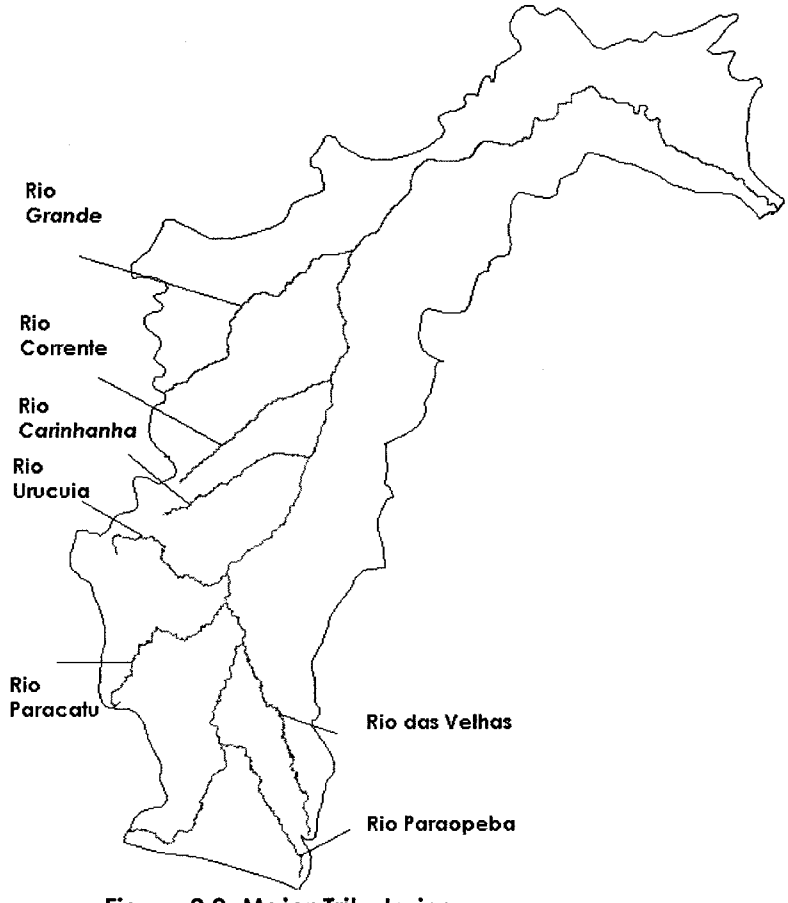

Figure 2.2. Major Tributaries
Source: derived from georeferenced data available from http://siscom.ibama.gov.br/shapes visited on October 10, 2009 (IBAMA 2009).

The Basin

The *São Francisco River* system drains an area of about 640,000 square kilometers, eight percent of the nation's territory (Figure 2.3 below). The basin is about three and a half times the size of New England. It comprises territories in six different states – Minas Gerais, Bahia, Goiás, Pernambuco, Alagoas, and Sergipe – and the Brazilian Federal

District. Nearly 48% of the watershed lies in the state of *Bahia* and 36.9% in *Minas Gerais* (CBHSF 2004).

Figure 2.3. Watershed vs. Country's Area
Source: derived from Georeferenced data available from http://siscom.ibama.gov.br/shapes visited on October 10, 2009 (IBAMA 2009).

Based upon the SFR's physical characteristics, such as the existence of rapids and falls, the SFR basin forms four sub-regions (Table 2.2 below): upper, middle, lower-middle, and lower. The upper-SFR has the highest number of inhabitants. The lower-SFR comprises the smallest and the middle-SFR the largest area of the basin (Figure 2.4 below).

Table 2.2. Geographic and Demographic Characteristics

Sub-Regions	Total Area in square km	Percentage of the Area in Relation to the Size of the Basin	Limiting Municipalities	Total Inhabitants	Percentage of the Population to the Total of the Basin
Upper-SFR	100,076	16%	From the source to *Pirapora* (MG)	6,247,027	48.8%
Middle-SFR	402,531	63%	From *Pirapora* (MG) to *Remanso* (BA)	3,232,189	25.3%
Lower-middle-SFR	110,446	17%	From *Remanso* (BA) to *Paulo Afonso* (BA)	1,944,131	15.2%
Lower-SFR	25,523	4%	From *Paulo Afonso* (BA) to mouth (AL and SE)	1,372,735	10.7%

Source of data: CBHSF 2004.

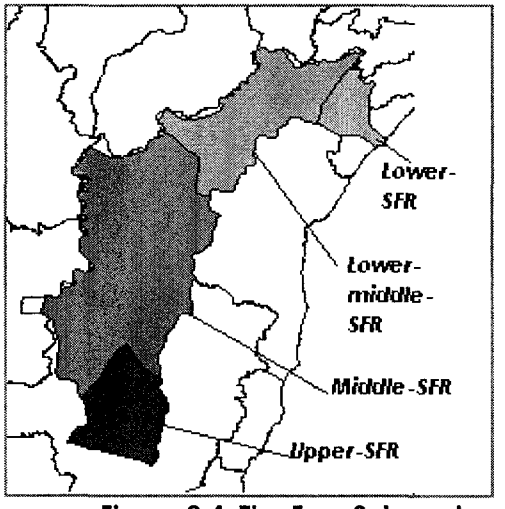

Figure 2.4. The Four Sub-regions of the SFRB
Source: derived from Georeferenced data available from http://siscom.ibama.gov.br/shapes visited on October 10, 2009 (IBAMA 2009).

Three climate conditions prevail: tropical humid, tropical semi-arid, and tropical semi-humid (SRH-MMA 1998). The birth of the SFR in the upper-SFR is located further from the Equator than the other parts of the river. That fact, associated with the high elevation contributes to lower climatic temperatures. However, most of the river and river basin are located in a climate region characterized by low precipitation and high temperatures,

particularly on the middle and lower-middle-SFR. The hot and humid climate of the Brazilian coastal zone influences the lower-SFR basin. In general, the precipitation level is high in *Minas Gerais*, where the river starts. Precipitation decreases as the river follows its journey north and east until its mouth, where the precipitation level rises again. In the upper-SFR in average rains about 54 inches per year and the temperature is of 73 °F. In the middle and lower-middle precipitation falls on an average of 41 inches per year in the middle and 27 inches annually in the lower-middle with average annual temperature of 75 °F and 81°F respectively. In the lower-SFR it rains an average of 38 inches/year with an average annual temperature of 77 °F (CBHSF 2004) (Figure 2.5 below).

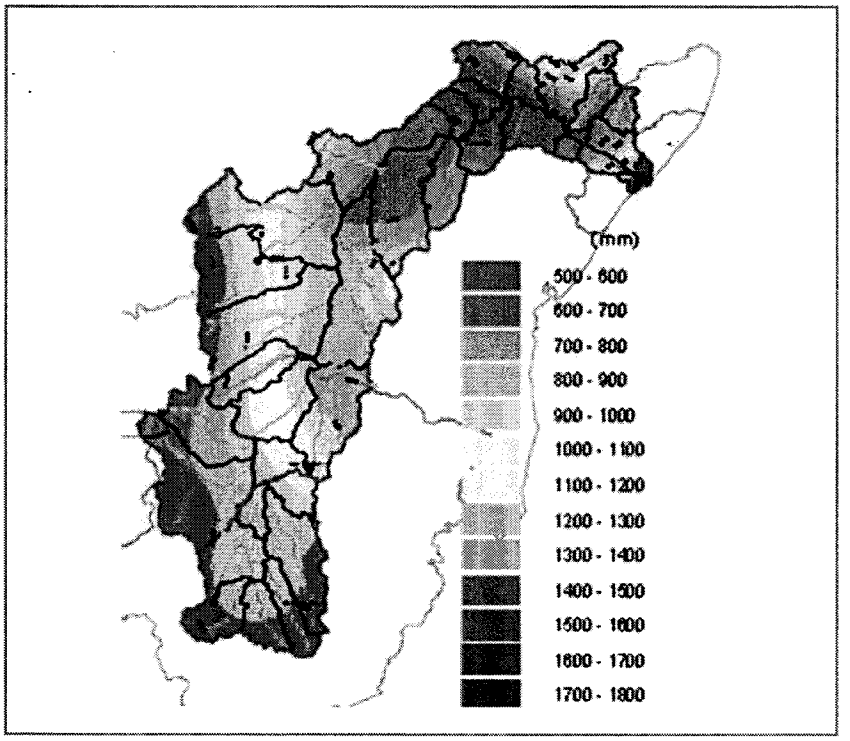

Figure 2.5. Average Annual Precipitation (in millimeters): 1961-1990[12]
Source: Modified from CBHSF (2004, 25)

In the semi-arid region, only two seasons exist: the "burning summers" ("*verões queimosos*"); and "pouring winters" ("*invernos torrenciais*") (Cunha 2005, 45). In the

[12] One-hundred mm is equal to 3.937 inches

upper-SFR and semi-arid region of the middle and lower-middle-SFR, the winter is referred to as the irregular and short raining season: the wet season. It centers on the South American summer in the months of November to January. In the lower-SFR it rains from May to June and August to September. The valley is susceptible to high evaporation rates. In the semi-arid that number can be in average 79 inches annually (CBHSF 2004).

Geographic uniqueness, such as the location of an extensive watershed area and river in the harsh semi-arid climate, explained the initial low level of occupation of some parts of the basin (Lopes 1950). Still today, the greatest population density is located especially in the upper-SFR where the climate is humid and in the semi-humid lower-SFR. Five-hundred and three municipalities and the Federal District have their areas integrally or partially in the basin, accounting for about twelve million and eight hundred thousand inhabitants, about eight percent of Brazil's population according to the 2000 census (CBHSF 2004).[13] Only one quarter of this number live in rural areas. Half of the total inhabitants of the basin live in fourteen municipalities with urban populations exceeding 100,000 individuals. *Juazeiro* and *Petrolina* are two of those cities (CBHSF 2004). A hundred and one municipalities have areas bordering the SFR (IBGE 2005). Population growth has increased the pressure over the natural system.

Analytical Model of the *São Francisco* River Basin System

This research uses the *São Francisco* River Valley, *São Francisco* River Basin and *São Francisco* River Watershed as interchangeable terms meaning the area of land from which the water drains into the *São Francisco* River and its tributaries. *São Francisco* River Basin system includes the *São Francisco River* valley/basin/watershed and its elements, such as non-human species and human beings, as well as natural and human-made

[13] About seventy thousand indigenous people inhabit the basin (Tomáz *et al.* n.d.).

components.[14] The literature review, interviews, and observations of the river's environment helped me to draw an analytic model of the SFRB system and its sub-systems, and to identify and point out important variables that drive that system, namely the droughts (Figure 2.6 below). Those sub-systems have affected both water quantity and quality.

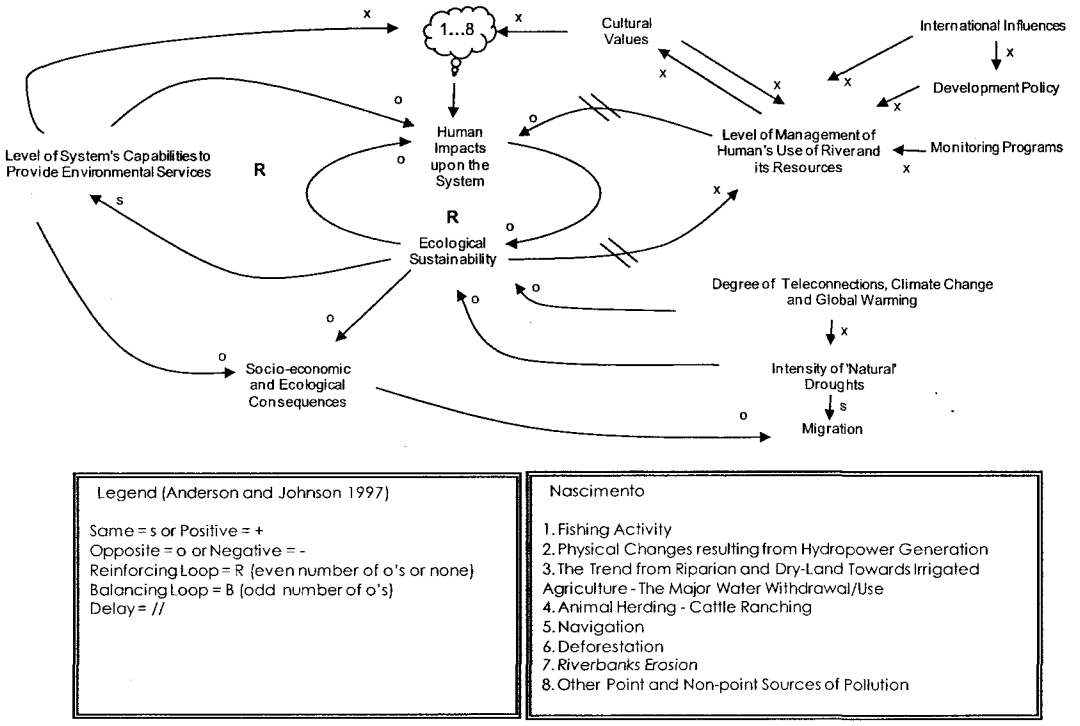

Figure 2.6. Analytical Model of the São Francisco River Basin System [15]

Floods, Droughts, and Migration

Important variables influence the SFR. This section describes three of them – floods, droughts and migration – and their interconnections.

Floods

Floods in the *São Francisco* River basin result from two main causes: excessive rain in the upper and middle-SFR and its tributaries; and torrential rain from *Sobradinho* to the

[14] A system is a complex whole composed of "interacting, interrelated, or interdependent components" with everything directly or indirectly connected (Anderson and Johnson 1997, 2).
[15] X means unclear effect or both directions: same and opposite.

sea (CODEVASF 1989, MME 1983a). Starting in *Pirapora* the river is surrounded by low lands (Rego 1936). Indeed, the middle-SFR is highly susceptible to floods. The water there flows very slowly. The river's slope is extremely low, accounting only for 110 m on a river's stretch of about 1,300 km long from *Pirapora* to *Sobradinho* (IBGE 1960, 70). Rain and inlets introduce into the *Velho Chico* a yellowish milk-and-coffee color, the "*new waters*" noted by Halfeld in 1860 (Halfeld 1860). Precipitation can be very intense in the semi-arid region. In a few days or in a month, the total expected rainfall for the year may come. Most of the time, the "...intensive water flow going into the S Francisco and sea's direction, ends as fast as it forms..." (Cunha 2005, 506).

Many have noted the benefits of flooding for the SFR system. Precipitation events and floods temporarily improved navigation. Boats could then easily navigate the SFR's waterway (Observador 1962). The overflow used to create lagoons, aquatic populations' nursery sites, boosting fishing. It formed riparian flood plains used for traditional agriculture (Sampaio 2002). Floods used to bring mud replenishing soil's nutrients and fertilizing riparian zones for agriculture. Small inundated area and a short flooding season or no flood often meant more poverty. The opposite was synonymous with abundance of food (Silva 1961). The comparison of the SFR with the Nile came from this fact and from the semi-arid zone that both rivers cross (Pierson 1972, vol. 1).

Nevertheless, flood events have also had negative effects. Flooded lagoons were the source of water-related diseases, such as *malaria*. Floods increased the speed of the waters, created new channels intensifying riverbank erosion and accentuated silting (Baity 1951). Inundations have destroyed riparian vegetation and new plantings during unexpected episodes (Rego 1936, Observador 1962). Floods have damaged properties such as homes and city's infrastructures. The problem has been aggravated by the occupation of frequently flooded areas.

The literature and local people's memories have singled-out extreme events. For example, the 1979 flooding season forced more than 220,000 people out of their homes (MME 1983a). It inundated seventy percent of the urban zone of *Bom Jesus da Lapa* and fifty percent of the town of *Pirapora*. It also worsened silting in that *Minas* town's river beach area (DNOS 1980).

The natural event triggered inter-ministerial committees and studies to propose alternatives to address the problem by the construction of walls, drainage system, and the relocation of people in the ten most affected cities. The committees suggested the use of existing reservoirs to control flooding (DNOS 1980, MME 1983a, Carvalho and Kotscho 1989).

Droughts: The "Tragic Variant" (*Variante Trágica*)[16]

Drought is the lack of water or a water volume below the average available under normal local conditions for humans and other species (Tallaksen and Lanen 2004). During droughts, the *São Francisco* River is an "oasis in the desert" and as expected, the size of population increases in riparian towns and cities which receive the environmental refugees known as *retirantes* (Sampaio 2002). Droughts are recurrent climatic events. The non-raining season occurs every year and is enough to make the local natural vegetation of the *Caatinga* biome composed of bushes and small trees, turn grey, except the cactuses. The longer lasting droughts are the ones that display the face of human tragedy.

The Brazilian literature has linked drought in the Northeast of Brazil to temporal and spatial inter-annual variability of rainfall characterized by the occurrence of: none, weak, or few shower events; precipitation converged in a short period of time, and rainfall set at large intervals. Droughts are influenced by the topography of the region,

[16] Euclides da Cunha (2005: 165) described the droughts in the Northeast of Brazil as a "*tragic variant*" ("*variante trágica*").

such as the *Borborema* Mountain-Range, which impairs rain coming from the Atlantic coast; and high soil reflectivity, which precludes cloud formation (Nascimento n.d., SBPC 2005, Serebrenick 1953).

Drought also has been connected to climatic anomalies such as *El-Ninõ*; distortion in the Atlantic Ocean surface temperatures, such as warmer in the north and colder in the south; and alterations in the position of air masses responsible for clouds and rain formation, the Intertropical Convergence Zone – ITCZ, when it is located further north than usual (Nascimento n.d., Davis 2001).

Water scarcity is aggravated by other factors: elevated numbers of rain-fed seasonal water bodies and the low capability to store water characteristic of the crystalline region's shallow soils deficient in organic matter (Nascimento n.d.). High temperatures, low humidity, strong winds and scarce input from rain contribute to a high index of evapotranspiration (Serebrenick 1953). Evaporation capabilities surpass water reserves. After a long period of drought, the first drops of rain fall over the hot soil and evaporate. The following drops form "barren rivers drawn at random," with water flowing away (Cunha 2005:69).

The existence of droughts is a triggering force for governmental work in the Northeast of Brazil. The issue has such importance that for policy purposes the federal government drew boundaries for a political-administrative drought-prone region, the *Drought Polygon* in 1936, an area of 672,281.98 sq km (CEAS 1971, MMA 2004). The National Department for Works Against Drought – DNOCS, created in 1945 and its predecessors agencies, have been working on preventive and emergency relief efforts to avoid a repetition of the consequences of the worst drought, the *Great Drought* of 1877-1879, in the history of the Northeast, when between 200-500,000 people died (Greenfield 2001, Davis 2001) and huge out-migration took place.

The size of the *Drought Polygon* determined for federal resource allocation has increased over time. The area now used is the semi-arid region as defined by the Constitutional Fund for Financing the Northeast – FNE. The fund resulted from the 1988 Constitution [Art. 159, I, c]. The area is a little smaller than one-and-a-half times the size of Texas. The semi-arid zone embraces towns and cities with average annual rainfall levels equal or inferior to 31 inches, high evaporation rates, and susceptibility to water deficit. The average annual temperature in the semi-arid is between 73.4 and 80.6 °F. The area is also highly vulnerable to desertification (MMA 2004). Some fifty-seven percent of the SFR basin is semi-arid (CBHSF 2004).

The consequences of droughts depend on their duration, volume, intensity, more specifically upon the period without the availability of water resources and also the extent of the region affected. Several authors have documented the social effects of droughts on local populations of the Northeast (e.g., José 1988, Cavalcanti 1988, Cerqueira 1988, Sampaio 1987, Ab'Sáber 1999, Kenny 2002). Besides the obvious effects on people, such as hunger and deaths indirect effects also exists. For example, dry land agriculture, which depends directly on the frequency, spatial distribution, level of rainfall and soil moisture, is highly susceptible to water scarcity.

Droughts lower the water flow and the resources available in reservoirs affecting hydropower generation, and consequently individuals and economic sectors that depend on electric power. *Companhia Hidro Elétrica do São Francisco* – CHESF is the major hydropower supplier in the valley. In 2003, seventy percent of the electricity sold by CHESF went to the capitals of the northeastern states, all of them located outside of the basin (CHESF 2003). The effects of drought in the valley are felt by a large share of northeastern population. CHESF supplies industries; households; public infrastructure; and federal, state, and local government agencies.

Migration: the Escape Valve

At the end of the nineteenth century, tens of thousands of Northeasterners migrated to the Amazon during the rubber boom (Oakenfull 1913). In the 1950s and 1960s, people left to join the labor forces of *São Paulo* and *Rio de Janeiro* and to build the new capital of the nation, *Brasília* (Ribeiro 2008). Indeed, following the trend of the broader region up until the 1960s, population movement in the SFRB had been mostly outward. This out-migration was initially spurred by the recurrent devastating droughts, concentrated land ownership, and prevailing agriculture production models, then by the prospect of wage labor in the urban construction and by the hope of higher living standards. Environmental refugees also sought water and shelter in the cities. Migration worsened social conditions in metropolitan zones, leading to the spread of shanty-towns (Araujo 2004).

In the 1950s, the number of individuals born in the Northeast but living outside of it grew at an annual rate of 8.8%, more than twice the corresponding rate of 3.7% in the 1940s. The lower-SFR lost significant population in the 1950s and 1960s (Moura 1979). On the other hand, the Northeast did not attract significant migratory inflows from other regions, except from *Minas Gerais* and *Espírito Santo*. In 1970, 99% of the population in the Northeast had been born there (Moura 1972).

The rural-urban migratory stream dominated in areas of middle and lower-middle-SF during the 1960s (Moura 1979). In the Northeast, rural to urban migration continued during the 1970s and 80s. Commerce and services attracted migrants to urban zones between 1980s-1995, despite an economic crisis that hit the urban-industrial sector harder than other areas (Perz 2000). Migration is an escape valve for the SFR system as well as for the *Drought Polygon*.

Migration is also associated with other causes. The introduction of the new development approach, the hydro-business, which is based upon hydropower and

irrigation, affected the local social order of traditional ranching and agriculture, commerce, and fishing towns. The development-induced displacements forced migration and adaptation to new ways of living, disconnected from the river (Collins and Krippner 1999). Examples of this tragic situation are provided by the *Sobradinho* and *Itaparica* dams which required the resettlement respectively of about 65,000 and 50,000 people (Collins and Krippner 1999, Gleick 1993, Cernea 1996). The construction of *Sobradinho* caused the relocation of four towns: *Remanso, Casa Nova, Sento Sé and Pilão Arcado*.

Today, irrigated agriculture attracts many to development "poles." Few find permanent work, while others are members of a contingent workforce which only finds jobs seasonally. "Elsewhere in the region, on the periphery of the urban settlements of *Petrolina* and *Juazeiro*, settlements grew up to house the influx of migrants who formed the primary labor supply for most farms" (Collins and Krippner 1999, 520). But, the number of people who arrive every day is higher than the towns and cities can support. As Hilton (1963) observed, the implementation of governmental projects would save migrants a long walk to *São Paulo*, the major receptor center of northeasterners in the Southeast of the nation.

Teleconnections, Climate Change, and Global Warming

Teleconnections are correlations among weather events which occur around the globe (Angstrom 1935, Barrett 1998). Teleconnections modify regional and global weather patterns and alter the hydrologic cycle. Droughts, floods, and other extreme events are the consequences of teleconnections. Anthropogenic influences on the Earth, such as the increase in the emission of greenhouse gases (e.g., carbon dioxide – CO_2, methane – CH_4, nitrous oxide – N_2O and chlorofluorocarbons – CFCs) are changing

the 'natural' global climate pattern too (IPCC 2001).[17] In addition, another process contributes to the heating of the planet: the holes in the ozone layer. The emission by human societies and the concentration of CFC gases in the atmosphere cause the depletion of the ozone layer, allowing an increase in the level of solar radiation which penetrates the atmosphere.[18]

Human-induced climate change and global warming are affecting the atmosphere (IPCC 2001a) and consequently teleconnections (Loboda and Svinarenko n.d.). Global and regional climate patterns result from interactions of variables such as atmospheric pressure and sea surface temperature (SST) (Barrett 1998). *El Niño*-Southern Oscillation (ENSO) is an example of such climate pattern (IPCC 2001a, NWS 2002). The consequences of ENSO in the northeast and southern parts of Brazil are opposite. Increase in rainfall in the South is associated with the occurrence of warm ENSO (IPCC 2001b, Davis 2001). Part of the SFR watershed is located in the southeastern region. In the Northeast, the *El Niño* is related to dry conditions. Such effects increase the water stress in the region due to the occurrence of deficient rainy seasons. In 2001, it reduced energy production (Magrin *et al.* 2007, IPCC 2001c). Climate change researchers suggest that El Niño-like conditions will continue to take place and will influence the already vulnerable population in the semi-arid of Brazil affecting the area in different ways, such as reducing the volume of water available and the decreasing agricultural yields (IPCC 2001c).

International Influences: Ideologies and the Market

The ideology of conventional economic development as the only model of 'progress' to be followed by Third World and developing nations is still present in the mind of politicians and/or members of the elites (D'Araujo 2007, Tauile and Faria 2005). But,

[17] Water vapor is a natural greenhouse gas (IPCC 2001).
[18] Despite the positive effects of the Montreal Protocol to regulate the use and phase out substances that deplete the Ozone Layer, the hole still exists, especially over Antarctica.

sustainable development and sustainability aims have been incorporated to national policies as in the 1997 Water Policy.

"Brazilian environmentalism" is a product of the 1970s, whose main goal was to bring environmental problems to the public view, with the state playing two contradictory positions, supporter and enemy. Brazilians returning home in 1979 after the long period of international political exile brought "green" ideas to the nation. The movement has been following a path of lows and highs, with environmental issues being placed behind political issues and economic interests (Viola 1997). The 1992 Earth Summit took place in *Rio de Janeiro* and again brought attention to the environmental problems of the nation.

Another global stimulus to the SFR system is its participation in world commerce as a supplier of agriculture products such as soybeans and fruits such as mango and grapes. It is an economic linkage. The market influences price, products and their characteristics. Brazil is also a signatory of international agreements and member of inter-governmental organizations. The purpose of the Water Policy for example resembles the 1992 Dublin Statement. One cannot ignore the effects of these external variables.

"Virtual Water" Trade and Virtual Environmental Degradation Trade[19]

A hidden dynamic occurs when a country or region exports an agricultural product: water is lost and environmental degradation is usually gained. Food production affects the natural systems in both hydrological and ecological ways. In the case of the

[19] According to the Oxford English Dictionary [Online, accessed Aug 12, 2006], the term virtual means "so in essence or effect, although not formally or actually; admitting of being called by the name so far as the effect or result is concerned". In this paper's context, virtual means that the water that made the production possible is not obviously perceived, does not go together in the same package of the fruit exported, but it was demanded and removed from its sources and will not return to the local or regional water system in the same quantity and quality as it was withdrawn. Virtual environmental degradation means the local or regional ecological consequences generated during the process of production of a good exported.

São Francisco, about 69% of the water withdrawal supplies the agricultural sector (CBHSF 2004). The total area of irrigated land is increasing, together with the water demand.

Tony Allan introduced the 'virtual water' concept in a seminar in 1993 (Allan 2003, Hoekstra n.d., UNESCO-IHE 2006). "The water that is used in the production process of an agricultural or industrial product is called the 'virtual water' contained in the product" (Hoekstra and Hung 2002). The 'virtual water,' and its amount of water that probably ended up being moved from the basin (e.g., evaporated), can be described as a hidden productive cost paid by local systems. Depending on the source of the resource, such as in the case of nonrenewable aquifers (e.g., fossil water), the water could be lost by the local system forever. It does not necessarily mean that after the productive process the 'virtual water' will be totally unavailable to local or regional systems as in the case of the real water contained in the crop exported. Some water goes away (e.g., run off to rivers and discharge into the sea), but some water stays. Local nature will recycle part of the 'virtual water' through the regional water cycle. Evapotranspiration from crops and land surfaces and subsequent precipitation, water runoff from surface and subsurface to local water bodies, soil moisture and infiltration to local renewable aquifers, all might still make some of the resource available to local ecosystems. As regards ecological considerations, the environmental degradation is real. Agricultural practices result in the subtraction of nutrients from local and regional systems and soil depletion (FAO 2004); as well as air, soil and water pollution from the addition of fertilizers and pesticides (Postel 1993).

Nations support the water needs of other countries (Hoekstra n.d., 1), and nations are inadvertently or deliberately polluting themselves for others. Brazil has historically played the role of a net exporter of primary products, and consequently 'virtual water', and has engaged in virtual degradation flows to world food markets.

World systems are connected via 'Virtual Water Trade' (Hoekstra n.d.). Grapes produced in the irrigated fields of the semi-arid region of the *São Francisco* River Basin, in Brazil, are consumed in countries of the First World such as the Netherlands. However, what is not recognized is that the Dutch are also consuming Brazilian water.[20] The basin loses water through export. When the valley exports products it is exporting water. But, it is also gaining environmental destruction with the use of agro-toxins and unsustainable agricultural practices. The fluxes of virtual and real water go both ways. This research does not assess the water budget.

The Sub-systems

This section describes the identified sub-systems of the *São Francisco* River Basin.

Fishing Activity

The Figure 2.7 below illustrates an analysis of fishing in the *São Francisco* River. Three major forces have affected aquatic species and fishermen's livelihoods: hydropower infrastructure, overfishing, and water pollution.

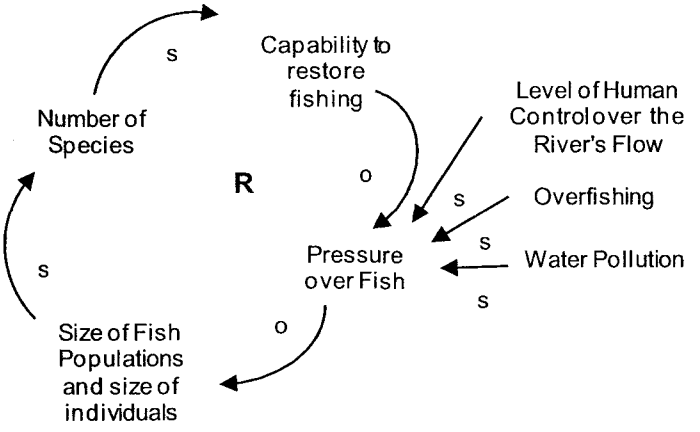

Figure 2.7. Fishing Activity

The SFR system is "strongly affected" by river fragmentation and flow regulation (WRI 2003). The once free flowing river system is now a sequence of water reservoir for

[20] 'Virtual Water Trade' as defined in Hoekstra and Hung (2002).

hydropower generation.[21] Nine dams and the human management of them govern the flow of the *Velho Chico*. Those changes have affected habitat and aquatic species, including migratory fish species unable to follow their reproduction pathways.

Three types of fishermen co-exist in the river basin: (1) commercial fishermen fish for income purposes; (2) subsistence fishermen fish to complement their diet, and (3) sport fishermen (anglers) fish for leisure. Members of the subsistence classification do not need a legal permit to fish, they only need to be included in a user database. But many of those grouped in the two other categories do not hold a license either (Gutberlet and Seixas 2003). A natural survival bias towards seeking the existence from the river was evident in the past, but environmental changes have increased such activities. In addition, it is also possible to find examples of overfishing in the literature, such as local people burning, tossing away and letting fish go rotten (Pierson 1972, vol. 2).

Fishing is highly regulated in the watershed and includes fishing closure, specifications of species and size of caught, and species prohibitions [Instituto Estadual de Florestas – IEF Portaria # 156 Nov 1, 2007].[22] State mechanisms strengthen federal instruments. Monitoring programs came into force especially during times when governmental rules shut down fishing (e.g., Fishery closure in *Pirapora* by IBAMA and IEF). The Labor and Employment Ministry pays an allowance to fishermen association's members to compensate for the four-month period without fishing (Diogenes 2002).

Agencies such as DNOCS, CHESF and CODEVASF have undertaken and supported both aquaculture and restocking programs in the valley. Program objectives include: increasing local population's income and consumption of fish, and mending the

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[21] Fish ladders were seen as inefficient in the case of *Três Marias* and *Sobradinho* Dams because their heights were superior to six meters. But, navigation locks could be employed during the fishing reproductive season to allow migration (LASA and TECNOSOLO 1962). Posteriori studies have shown that the height of the ladder is one among many important variables that influence the success of migration. The outcome is also associated with the design of the ladder, and the species, size and age of the fish (Orsborn 1982-84, Fernandez *et al.* 2004).

[22] The interval for 2007-2008 reproductive cycles was from November 1st, 2007 to February 28th, 2008 (Instituto Estadual de Florestas – IEF Portaria # 156 Nov 1, 2007).

socio- economic consequences of development projects (CVSF 1957, Souza 1979, CODEVASF 1992, Goncalves Neto 2001, Silva 2005, Araújo and Sá 2008). Those efforts have not been enough to address the problem.

In addition, land use change and water pollution from domestic and industrial sewage and mining, displacement from waterfront's lands have affected the fishery. The 1997 Water Policy has the jurisdiction to influence two of the pressures over fishing: water pollution and management of hydropower infrastructures.

Physical Changes Resulting from Hydropower Generation

The demand for hydropower in a nation pursuing the path of development has driven this sub-system.[23] Hydropower infrastructures and their management have led to changes in the landscape, and in both water and sediment flows. It has affected the provision of other ecosystem services too, disturbing fish, the fishery and fishermen and traditional riparian agriculture. The Figure 2.8 below represents the case of hydropower generation in the *São Francisco* River:

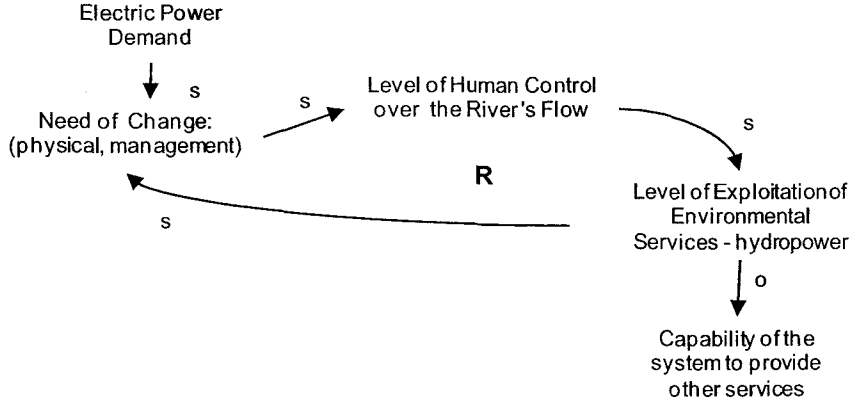

Figure 2.8. Hydropower and Physical Changes

[23] The reasons why the federal government chose the industrialization-urbanization development pathway, influencing the use of the SFR, are described in Topik 1985, Goldsmith 1991, Silva 2003, and Nascimento 2010.

Between 1930 and early 1990s the state provided, among other things, investments in basic inputs and infrastructure. The pro-growth state developed the areas which the private sector did not want or could not undertake (Frieden 1981). Some sectors were thought to be the state's business. For example, the 1934 Constitution [Art. 118, Art. 119] and 1934 Water Code [Art.43, Art. 63, Art. 139] established that industrial use of the waters such as for hydropower shall be undertaken/overseen by the state [1934 Constitution, 1934 Water Code].

Given the prevailing postwar understanding of development, the country required electric power for its progress. By the 1950s, electrical shortages and a growing demand for power was a challenge for Brazilian development (Brewer for The New York Times 20 Nov 1954). The federal government sought to change that. Indeed, in the *São Francisco* Basin, the first station producing electricity on a large-scale went on-line in 1954, *Paulo Afonso* I. Through power lines, electricity started to flow outward from the valley in the same year (CHESF 1998). CHESF sent the power especially to coastal cities while *Sertão* towns waited for it (IBGE 1960b). CHESF's energy also triggered the formation of states' power distribution companies that replaced municipality and states' previous smaller systems (Dias 1993, CHESF 1998).[24]

Another fact contributed to the deficiency of electrical power links to zones in the countryside, the lack of rural organization (Yuri 1961). Contrary to the information given on The New York Times' ad about the scheme, to attract foreign investments, the "ambitious project" did not "benefit all the vast North-Eastern area of the country" as it was supposed to do (The New York Times 06 Jan 1954).

A new notion of the *São Francisco* River was emerging. In the post-1950 era, federal policies for the Northeast went beyond mitigation of the consequences of droughts and started to focus on issues related to development, following an *economic*

[24] In the 1990s, under the neoliberal age, governments privatized power companies, such as COELBA in *Bahia* in 1997.

approach. The geographical distance increased between the river and the users of its resources. The ecosystem services started to influence the lives of individuals living far away. The river and users came to be more and more distant from one another. It created an unseen and more unperceived, but strong dependence level. It fostered a connection between human beings and the river environment which supplied the electrical power.[25]

In the 1960s, hydro provided over sixty-five percent of the nation's electricity, a share which steadily grew into the 1980s (IBGE 2003). The Northeast continued expanding infrastructure, especially transportation and electrical energy (Araújo 2004). In the late 1960s and 1970s, state-sponsored projects and an indebted nation dependent on foreign loans, characterized hydropower and industrial expansion (Frieden 1981). During the seventies alone, four new stations started producing energy using the *Velho Chico*. In the 1970s and 1980s, among other sectors, public investments in the Northeast were visible and benefited electrical energy and irrigation as well (Araújo 2004). The demand for electricity in the Northeast is estimated to increase on an average of 6% per year for the period of 2004-2014 (CHESF 2005) (Table 2.3 below).

Nine dams control *Velho Chico*'s flow. *Companhia Energética de Minas Gerais* – CEMIG (*Três Marias*) manages one and *Companhia Hidro Elétrica do São Francisco* – CHESF controls eight of them (Table 2.4 below). The installed hydropower capacity can generate a total of 10,364 megawatts of energy. In a larger scale, the damming of the SFR significantly shifted the meaning and use of the river from multiple to single, hydropower, and later to duo purposes: hydropower and irrigation.[26]

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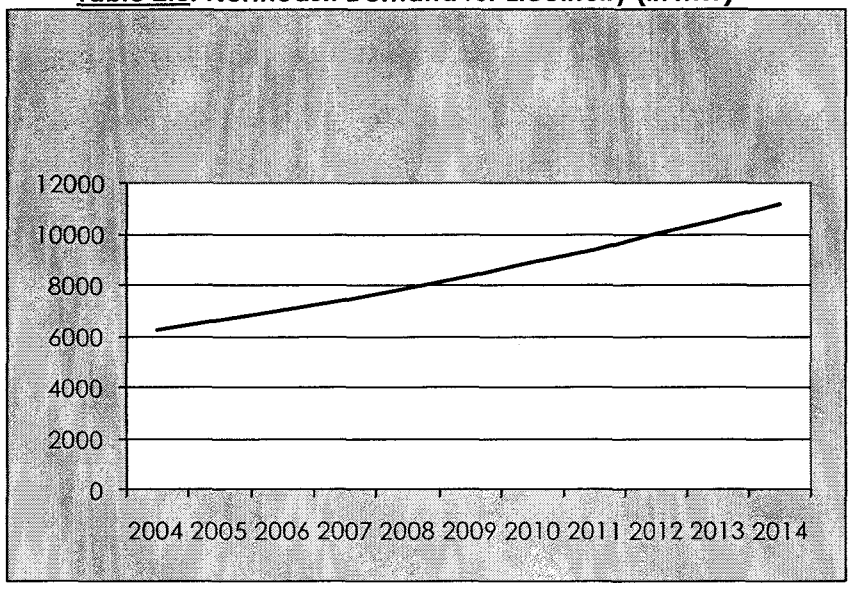
[25] In 2001, a fact showed that, the strong dependence still exists. Drought caused water shortage, which led to black-outs and a temporary mandatory electricity consumption reduction program (Tribuna do Norte 2001, Radiobras 2001).

[26] About 69% of the water withdrawal in the São Francisco watershed supplies the agricultural sector (CBHSF 2004).

Table 2.3. Northeast: Demand for Electricity (in MW)



Source of data: (CHESF 2005)

The natural system shows signs of ecological stress due to many causes, including hydropower (e.g., CBHSF 2004, Pompeu *et al.* 2006, IGAM 2008). The maximum physical exploitation of the *Velho Chico*'s electrical power has not been exhausted. The federal government has started a bidding process or 'call for projects' for the construction of another hydropower station in the lower-SFR, the *Usina Hidroelétrica de Pão de Açúcar*. It will be located at forty kilometers downstream *Xingó* and 170kms from the river's mouth. CHESF no longer holds the right of use (concession) of the SFR for new hydropower developments (ANA *et al.* 2003b). Besides *Pão de Açúcar, Riacho Seco* and *Pedra Branca* both to be laid downstream *Sobradinho* are two hydro electrical complexes among others discussed to dam the SFR in the future. In addition, the plan to build Brazilian new nuclear facilities has thought of the *São Francisco* as a potential location too. A possible site, in a tri-state location would "benefit" three states: *Alagoas, Bahia* and *Sergipe* (Vasconcelos for A Tarde 03 March 2010). The basin also has thermoelectric stations such as the one in *Petrolina*.

Table 2.4. Hydropower Stations and Reservoirs

Hydropower Stations and Reservoirs				
Operator – Unity – Reach of the River	Date went on-line	Capacity (mega watts MW)	Reservoir	Reservoir Area Reservoir Volume
CHESF – *Paulo Afonso* I Lower-middle-SFR	1954	180	*Emílio Gouvéia*	4,8 km^2 26 Hm^3
CHESF – *Paulo Afonso* II Lower-middle-SFR	1961	443	*Emílio Gouvéia*	4,8 km^2 26 Hm^3
CEMIG – *Três Marias* Upper-SFR	1962	396	*Três Marias*	---- 15,278 x Hm^3
CHESF – *Paulo Afonso* III Lower-middle-SFR	1971	794	*Emílio Gouvéia*	4,8 km^2 26 Hm^3
CHESF – *Apolonio Sales* Lower-middle-SFR	1977	400	*Moxotó*	98 km^2 1,150 Hm^3
CHESF – *Sobradinho* Lower-middle-SFR	1979	1,050	*Sobradinho*	4,214 km^2 34,116 Hm^3
CHESF – *Paulo Afonso* IV Lower-middle-SFR	1979	2,460	*Paulo Afonso* IV	12,9 km^2 127,5 Hm^3
CHESF – *Luiz Gonzaga* Lower-middle-SFR	1988	1,479	*Itaparica*	828 km^2 10,782 Hm^3
CHESF – *Xingó* Lower-SFR	1994	3,162	*Xingó*	60 km^2 3,800 Hm^3

Source of data: (CHESF n.d.b.; CEMIG 2002)

Hydropower station companies pay financial compensations to municipalities, states, the Federal District and the Union for the use of water resources for power generation within their boundaries [1988 Brazilian Constitution]. The value is based upon, among other things, the amount of energy produced and the area flooded by reservoirs. Brazilian energy consumers pay use fees to electricity distributors. Hydropower has played an important role as an electric energy source in the nation. In 2008, including imported amounts (8.4%), 81% of the total electric energy supplied in Brazil resulted from the power of the waters (MME 2009). Based upon installed capabilities, the *São Francisco* River has helped a mixed public-private enterprise, CHESF, become the largest hydropower generator in the nation.

The Trend from Riparian and Dry-land toward Large-scale Irrigated Agriculture

Farmers were owners of their land, or renters paying for the use of the terrain with money and favors, or workers in the system of sharecropping. These ventures and cattle and goat rearing framed and guided the economic and social arrangements in the countryside of the Northeast of Brazil.[27] But, pro-energy policies favored large-scale irrigated agriculture in the *São Francisco* Valley, by providing a steady water supply and the electricity to pump it. Moreover, the federal government has directly implemented policies for the agricultural sector, such as irrigation projects. The system below (Figure 2.9) illustrates the shift from dry-land to irrigated agriculture:

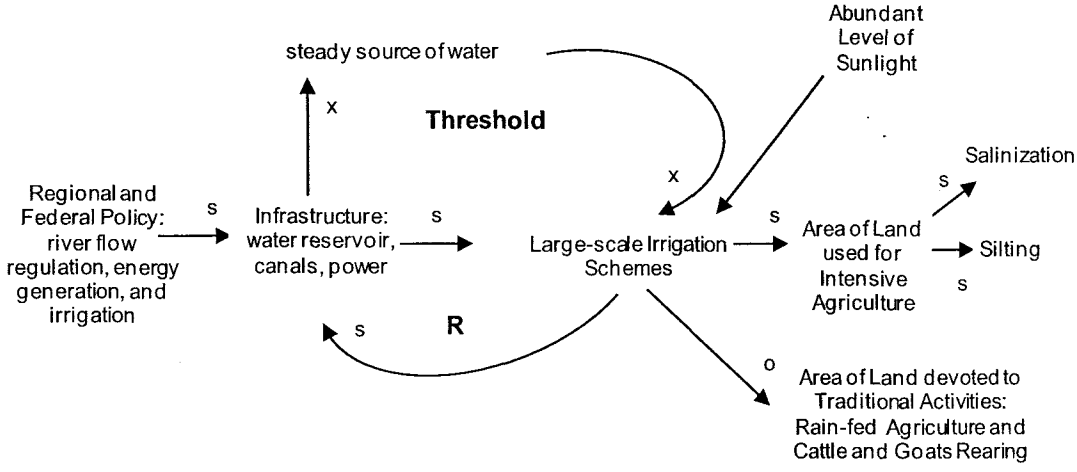


Figure 2.9 Agriculture

Riparian communities practiced agriculture on riverbanks and islands occasionally flooded by the river in zones subjected to the natural cyclical rise and fall of the waters (Pereira 1946, James 1948). The local population also farmed the humid lands that surrounded the reservoirs that federal agencies or private individuals built to alleviate the problems the drought caused (James 1953). The sediments once deposited naturally fertilized the area, allowing the culture, along permanent and intermittent watercourses, of short-term crop species in periods between floods. The river replenished

[27] Cattle and goats rearing are described later.

the nutrients and transformed the floodplains into productive soils (James 1952). Local farmers cultivated a little bit of everything. The level of subsistence from such activities was great. In the lower-SFR, for example, locals practiced riparian agriculture in lagoons (Pierson 1972, vol. 2). Neighboring areas integrated small plots of land with multiple subsistence crops.

In his 1950s' study, Pierson (1972, vol. 2) listed the major agricultural products of the valley, besides animal products, as: manioc, corn, and beans. On smaller forms, the area yielded rice, castor beans (*Ricinus communis*), cotton, and sugar-cane used to produce sugar-cane cake and alcohol beverages. Locals also grew fruits and vegetables. Riparian and intermediary zone communities extracted and collected honey, fruits, leaves, and seeds, namely, *carnaúba* palm for wax (*Copernicia prunifera*), *caroá* cactus for fiber (*Neoglaziovia variegata*), and *babaçu* coconuts for oil (*Attalea speciosa*) (Crist 1944; Pereira 1946; James 1948; Hirschman 1963; Azevedo 1968, vol. 2; Pierson 1972, vol. 2; Silva 1961).

People living in the riparian zones, *beiradeiros*, or in the river bank's edges, *barranqueiros*, also fished for subsistence and sold wood to the river steamboats (Burton 1869; Azevedo 1968, vol. 1; Bisilliat 1986).[28] With few exceptions, such as cotton and castor seeds that supplied the southeast of Brazil, local markets consumed most of the agricultural products (Pierson 1972, vol.2).

'Overcoming' the Limiting Factors. Away from the river, water proved to be one, among many, limiting factors. Agriculture in non-fertile soils and in areas susceptible to droughts posed challenges. For example, in the 1950s, James and Faissol (1956) predicted that agriculture would be an almost impossible task in the *Cerrado*'s fields given the way in which agriculture was done. New techniques would have to include "dynamite" and "bulldozers" (James and Faissol 1956). Agricultural techniques in most

[28] The two terms, *beiradeiros* and *barranqueiros* are often used interchangeably.

places in the basin, as in the medium-SFR, were similar to those used decades and even a century earlier (IBGE 1960). Slash and burning was a common practice (Silva 1961).[29]

Sunlight abounded and the weather was hot during the entire year, increasing the need for water, a scarce resource away from the river. In the *Sertão*, "everything is happy near by water" (Rosa 1983: 24). If it has water, everything flourishes. Nonetheless, it would be impossible to irrigate the whole area of the basin given its ecological characteristics. Some fifty-seven percent of the watershed is subjected to the semi-arid climate (CBHSF 2004).

Many have long recognized the possibilities of irrigated agriculture in the valley (Burton 1869, 1977; Rego 1936; Pierson 1972, Vol. 2; Rocha 1983). By the 1940s, private, regional and federal governmental entities had already attempted to establish small agro-industrial areas in the basin (Novaes 1989, Zarur 1946, USBR and SUVALE 1974a).

The 1950s introduced a new phase. Developmental policy emphasized small-scale irrigated agriculture of crops such as onions and corn (Damiani 2003). During 1950 and 1952, CVSF, a federal development agency for the watershed financed 1,250 engines to pump water from the SFR to irrigate riparian land, especially in *Bahia* and *Pernambuco* and in the lower-SFR (SUVALE 1968a, Novaes 1989). CVSF also introduced the use of tractors in the valley through its Mechanized Patrols (*Patrulhas Mecanizadas*) (Novaes 1989). The efforts increased acreage planted and output. By 1956, for example, production of onions exceeded the capacity of transportation. Onions from the valley reached *Ceará, Pernambuco, Alagoas, Sergipe, Bahia* and the southeast of Brazil (O Globo 27 Aug 1958, IBGE 1960). River navigation, railroads and roads transported onions and rice (O Globo 27 Aug 1958). A ship, the *Bocaína* even carried the cargo from *Penedo* to the south on a regular base (O Globo 27 Aug 1958).

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[29] Logistics did not favor the development of large-scale production systems either (Crist 1944, IBGE 1960, Duarte 1971).

CVSF and the anti-drought agency, DNOCS supported other irrigation efforts in the region and products including vegetables, citrus fruits, manioc, guava, and coconut (Yuri 1961). An Israeli mission worked in agriculture projects especially with DNOCS in the Northeast. From 1962 to 1968 the mission used experimental fields in *Petrolândia* to produce higher quality seeds of sorghum, hybrid corn, cotton, and greenery (Souza 1979). SUVALE, formerly CVSF, contracted private companies to study soil and irrigation and also received the technical support of the Bureau of Reclamation and the Department of Agriculture of the United States for planning, staff training, and extension assistance from 1969 to 1973 (SUVALE 1968; USBR and SUVALE 1974a, 1974b).

In addition, the Northeast Development Agency (*Superintendência de Desenvolvimento do Nordeste*) – SUDENE took a big step toward promoting large-scale irrigated agriculture. In 1960, it created the *São Francisco* Irrigation Group (*Grupo de Irrigação do São Francisco*) – GISF (SUDENE 1979). The United Nations supported SUDENE's irrigation projects (SUDENE 1979). The venture studied the possibilities of large scale irrigation in the lower-middle-SF and trained staff in irrigation related issues (SUVALE 1968a, Simões 2001, Chilcote 1990). By that time, the area still applied primitive methods, such as water-table farming (Hilton 1963).

The study led to the creation of irrigation pilot-projects, in some cases partly implemented by the GISF, such as the Irrigation Project of *Bebedouro* (*Projetos de Irrigação de Bebedouro*) of 2.240 ha, and Irrigation Project of *Mandacaru* (*Projeto de Irrigação de Mandacaru*) of 400 ha. The first experiments in the station of *Bebedoro* applying agronomic and irrigation techniques started in May 1963. SUDENE sought to make it an irrigation and settlement project (Hilton 1963). *Bebedouro* and *Mandacaru* experimented with food and non-food products, such as grass and cotton (Chilcote 1990). The first products in governmental public projects were subsistence goods (e.g., beans, corn, cotton), followed by *olericulture* (e.g., melons, onions, tomatoes, peppers),

and then permanent fruit-culture (e.g., mango and grapes) (Codevasf staff, personal communication, 04 Aug 2006, *Juazeiro*-BA). *Bebedouro* produced subsistence crops, such as beans, corn and later on cotton. Those would meet the needs of local families and the surplus could be sold in the market. Crops for commercial use would create labor opportunities (Hilton 1963). According to a former *Bahia* state Deputy, Manoel Novaes (Novaes 1989), the projects had great intentions: production of food and jobs to meet locals' needs. Irrigation would bring work and wealth for local families (Novaes 1989). But, the implementation costs would be too high and the economic returns too low, and there was no local market for high value crops (Hilton 1963). The projects imposed socio-political changes in the old patronage system (Chilcote 1990). The settlers were now under the rule of the project's technicians and not of members of the ruling classes.

In 1967, SUVALE replaced CVSF and moved away from the initial focus on colonization of small areas of land between 6 and 8 ha by families, to introduce small private companies with area up to fifty hectares (Novaes 1989). In 1968, farmers received the first irrigated lands in *Bebedouro* Project, in *Petrolina* (Otero 1969). SUVALE also took charge of *Bebedouro* experimental project and other irrigated land in the valley (Chilcote 1990, SUDENE 1979).

In the late 1960s, four ministries created an irrigation group GEIDA (*Grupo Executivo de Irrigação para o Desenvolvimento Agrícola*) (SUVALE 1968a). GEIDA contracted a consortium of two companies to form a multi-annual irrigation program (*Programa Plurianual de Irrigação*) – PPI, which included a scheme for the valley headed by Interior Ministry and implemented by SUVALE in early 1970s (SUVALE 1973a). CODEVASF, which replaced SUVALE in 1974, shifted toward reducing its influence upon the projects leaning towards the model that exists today. Besides governmental

companies and agencies, cooperatives were managing government irrigation projects with CODEVASF's support (Simões 2001).

In the present century, the SFR basin includes agro-industrial centers of dynamic growth referred to as "poles" (Araújo 2004). Each cluster includes projects with small (less than 10 ha), medium (between 10 and 40 ha) and large (more than 40 ha) governmental and private enterprises (CODEVASF staff, PC, 04 Aug 2006, *Juazeiro*-BA). Irrigation in the basin is mostly located in seven zones of development, plus areas around Belo Horizonte and the Brasília-Federal District (CODEVASF 2006a, CBHSF 2004). Water canals and drainage systems, pumping stations and roads comprise the structure. The improvements attracted and benefited private entrepreneurship too. Only thirty percent of irrigated land of the basin was in governmental projects in the beginning of the twenty first century (CBHSF 2004). Two systems co-exist: irrigated zones intra-perimeter, where CODEVASF and its predecessors made investment in infrastructure, and in extra-perimeter, where the owner provided irrigation infrastructure.

The *Petrolina-Juazeiro* agro-industrial pole is the largest irrigated zone. It centers in *Petrolina-Juazeiro* but also includes the towns of *Casa Nova, Curaçá* and *Sobradinho* in *Bahia*; and *Santa Maria da Boa Vista, Orocó* and *Lagoa Grande* in *Pernambuco* (Damiani 2003, França 2000). The pole incorporates the lower-middle region of the São Francisco River Basin. The pole is composed of different irrigation zones, such as *Mandacaru, Maniçoba, Tourão,* and *Curaça* in *Bahia*; and *Bebedouro, Nilo Coelho* and *Maria Teresa* in *Pernambuco* (Correia *et al.* n.d.). In 2001, the Federal Complementary Law# 113 authorized the creation, and the Law # 4,366 of 2002, which regulated the *Petrolina-Juazeiro* zone for administrative purpose such as to implement integrated management of resources, to develop programs, and to receive resources from the three different levels of the government. The complementary law reinforces the idea of a unified area of development, which is a pole.

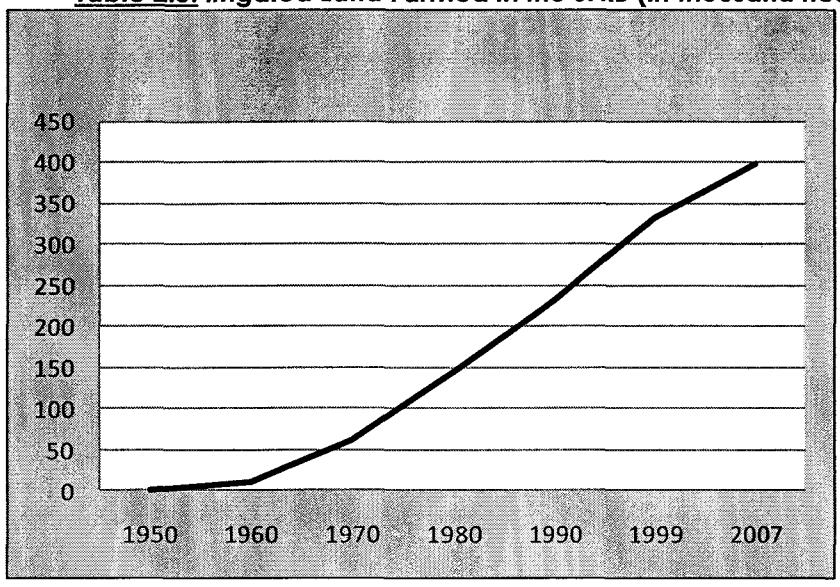
The waters of the SFR basin feed irrigation zones. Only the costs of infrastructure in governmental irrigated areas, such as the price for the electricity used to deliver the water is charged-for. The water has been free. In practice it has acted as a subsidy to lower the price of products.

Water quality and quantity issues have been a reality in irrigated and colonization perimeters. Individuals in the federal colonization project in *Serra do Ramalho* (*Projeto Especial de Colonização Projeto in Serra do Ramalho*) nearby *Bom Jesus da Lapa* created to receive the people displaced by *Sobradinho* have struggled since 1976 with the lack of potable water (Barbosa 1995). Highly saline water has come from the region's wells (Barbosa 1995). Not all irrigation projects have been fully implemented, for example, as in the case of the *Salitre* in *Juazeiro-Petrolina* region (rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA). In addition, *Salitre* Basin has been a battlefield of water conflicts.[30] The stream used to be a permanent river (Pierson 1972, vol.1). Today it is an intermittent water body. Disputes in the watershed have led to deaths (rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA).

Irrigated agriculture is increasingly practiced. Some 69% of the water withdrawal in the *Velho Chico* watershed supplies the agricultural sector (CBHSF 2004). By 1960, in the *São Francisco* River Basin, 10,800 ha were irrigated. By 1999, that number was 333,000 ha (Table 2.5 below). The changes showed an average annual growth rate of 9.2% for the thirty-nine year period. By 2007, the National Water Agency predicted that about four hundred thousand hectares were irrigated in the watershed [ANA Resolution# 145 of 2002].

[30] *Salitre* River Basin is 14,136 km^2 large [Bahia Decree# 10,197 of 2006].

Table 2.5. Irrigated Land Farmed in the SFRB (in thousand hectares)



Source of data: CODEVASF 2006b, ANA Resolution# 145 of 2002.

Irrigation allowed agricultural production beyond riparian and rainfed-dryland agriculture (Barros *et al.* 2004). Production became less dependent on the variability of the semi-arid rainy seasons. It permitted crop diversity, as well as spatial and temporal changes such as the location of the area of production and time of the growing season in relation to the year. The lack of rain is now an advantage allowing a more controlled environment (Marsden 1997). Irrigated agriculture has transformed the landscape. Permanent and temporary crops and water canals contrast with the *Caatinga* and *Cerrado*.

Nevertheless, the "reshaped environment" is also subjected to long-term risks and environmental effects, such as soil salinization, desertification, destruction of soil's organic matter and so on (Marsden 1997)."We practice agriculture against the Ecology" of the Northeast (Andrade and Duque 1971). The management of hydropower infrastructure for energy generation and irrigation has altered the traditional way of life. Riparian communities do not know when the river's water will be high or low and when and where to plant in riparian zones.

Besides irrigation, intensive planting requires the addition of nutrients. For example, in general terms, in the lower-medium SFR, the soil is sandy, has a low nutrient retention capacity, is poor in organic matter, and nitrogen is a limiting factor (Faria *et al.* 2004). Large-scale agriculture in the valley benefits from the low prices of land and workforce (Cardoso and Souza 2000). [31] Natural conditions favor the production too. The *São Francisco* Basin has high annual temperature and lots of sunlight (Voth 1999, Cardoso and Souza 2000, EMBRAPA n.d.a.). Also the low humidity is unfavorable to the development of plant diseases (CODEVASF 1989b).

Hydropower infrastructure made possible the existence of larger-scale irrigation systems such as canals and pumping stations (Collins 1993). But, it changed the socio-economic dynamic of the place. Since the 1970s, the area devoted to growing traditional products (e.g., cotton, manioc) decreased in the Northeast (Araújo 2004). In the *São Francisco* Valley, higher market prices have led to the increase of the production and importance of non-traditional crops, such as fruit (e.g., mangoes and grapes), raw material for food processing (e.g., tomatoes) and other industry (e.g., sugar-cane) (Araújo 2004, Silva *et al.* 2000, Collins 1995). Irrigation has visibly caused a shift from subsistence to large-scale agriculture. These *poles* of development are usually associated with and surrounded by areas of non-development (Marsden 1997). In the Northeast of Brazil and in the valley, studies have revealed the disparity among modern corporate agriculture and traditional communities. Critics assert that projects do not meet their goals regarding poverty alleviation especially during the occurrence of droughts (Caviedes and Muller 1994). Besides land concentration support the traditional power structures of the Northeast (Araújo 2004, 25).

Based upon the standard set to maintain its ecological discharge, the use of the water resources of the *Velho Chico* is reaching its threshold level for ecosystem collapse.

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[31] According to CODEVASF (2006d), based upon a report published in 1989, in the Northeast of Brazil the price of the hour of work was US$ 0.75, and in California US$ 5 to 10.

The National Water Agency has issued use permits for a total beyond the available resource since a volume of 1,300 m^3/s of water needs to be the minimal level of discharge in the river's mouth to assure its ecological sustainability [ANA Resolution# 412 of Sep 22, 2005, CBHSF 2004]. In the future, managers will need to choose among irrigated agriculture, electricity or other uses. For example, if the inter-basin water transfer project (*Transposição*) takes place as proposed, the scheme will reduce *São Francisco* Hydropower Corporation – CHESF's generation by 2.4% (MIN 2004). The project will benefit irrigated agriculture. Nonetheless, a limit exists regarding how much land the river's water is able to irrigate.

Internal and external political, economic and societal decisions and priorities have also influenced governmental and private choices regarding the valley (Carvalho and Silva 2008). The World Bank has financed the construction of infrastructures, such as hydroelectric dams and irrigation programs and the level of indirect outside policy influence upon the basin increased after the 1980s. Brazil has implemented structural adjustment programs mandated by the International Monetary Fund in exchange for loans. These institutions have promoted the production of agro-exports in Third World countries (Kayatekin 1998). In addition, today's First World consumers are powerfully influencing what products with which characteristics (e.g., freshness, taste/sweetness and size/weight) are grown in the valley as analyzed in the commodity chain literature (Collins 2000).[32]

Irrigated agriculture reshaped and has created vulnerability in the valley (Marsden 1997). The dependence on international markets made the basin susceptible to global crisis and fluctuations in the level of demand and price. It exposed the system to international market forces and product requirements (Duarte 1971). The new human uses of the valley's water re-conceptualized the good and the bad. The lack of rain was

[32] For more on commodity chain analysis see Topik, S *et al.* (ed.). From Silver to Cocaine: Latin American Commodity Chains and the Building of the World Economy, 1500-2000. (Durham, N.C.: Duke University Press). 2006.

unfavorable for inland agriculture exhibiting local's vulnerability to droughts (Silva 1961). But in the irrigated, controlled model of agriculture, rain became an uncontrollable variable that can damage agricultural production (Marsden 1997). Rains disrupted the planned nature of irrigated agriculture. For example, grape production in *Juazeiro* and *Petrolina* underwent two hardships in 2009. The economic crisis reduced the international demand and the unexpected high volume of rain reduced the productivity (Gomes 2010).

Irrigation has many costs, such as intensive use of water, fertilizers and selection of products based upon an export market oriented approach and not on local people's needs. Indeed, as a geographer and historian who knew the Northeast as almost no one else, Manuel Correia de Andrade once wrote, "People of *Sertão* should not be forgotten. They should be the subject of any policy for self-sustained development" (Bloch 1996, 9).

Animal Herding: Cattle Ranching and Goat Rearing

Large-scale irrigation schemes, the use of the zone for hydropower infrastructure and urban areas have reduced the land devoted to traditional activities, such as extensive cattle and goat rearing.

"These four-footed invaders asked but three things of their environment: water, grass, and salt" (Nash 1926, 251). The SFR basin initially offered open grasslands for cattle and goats (Nash 1926). The valley contained salt deposits (IBGE 1960). But, this product later on also came from outside of the valley (e.g., Rio Grande do Norte), distributed through *Juazeiro* (IBGE 1960b). The *São Francisco* and its tributaries served as source of the first needed survival element, water.

The importance of the basin for cattle ranching began in colonial times. Sugar-cane production took place in the humid coastal zones' land (*massapê*) and created

the demand for draft animals, food and other items of animal's origin, such as leather for clothing. In some early periods, skins were the principal product (Crist 1944, Azevedo 1968 vol. 1; CODEVASF 1978; Rocha 1983, Brandão 2007). Locally, animals also provided milk (Pierson 1972, vol. 2).

The environment was harsh. For example, a FAO report noted that in the middle-SFR, the area most susceptible to droughts, the livestock health ranged from well during the wet season to skeletons during dry time (Hilton 1963). Cattle ranching had an extensive nature occupying especially the *Caatinga* biome. Rare spots of humid lands held higher animal density (Rego 1936, IBGE 1960). Goats have resisted the difficulties of the region, namely arid climate, lack of water and food. Large areas are necessary to provide food to animals in the *Caatinga* region. Even cactus species have served as food during drought events (Pierson 1972, vol. 2). In the Cerrado biome region, locals burned fields when the first rains arrived to have a better field, with richer and newer grasses.

Meat from that area was not an international export product. Other subsistence activities were associated with cattle ranching and goat rearing. The population grew vegetables and raised sheep, pigs, horses, mules and donkeys (Azevedo 1968, vol. 2). But, cattle and goats were the two most important types of animals, making even crop based agriculture a secondary activity in the basin (James 1953, IBGE 1960).

Researchers have compared the social aspects of cattle ranching with feudalism (Brandão 2007). Large ranchers 'employed' workers for cattle handling, and to extract and sell lumber to steamboats (Pereira 1946). The staff, *vaqueiro*, worked under informal contracts and the payment was usually one animal for each four born alive in the herd of cattle he watched over.[33] The valley supplied cattle to *Pernambuco, Bahia, Minas Gerais, Rio de Janeiro,* and *São Paulo* (Rego 1936; Valverde 1944; IBGE 1960b; Pierson

[33] *Vaqueiros* wore leather clothes to protect themselves from the hush environment which included thorny vegetation.

1972, vol. 2). For example, *Estrada das Boiadas* was a crucial muddy trail that linked *Juazeiro* to the growing capital, *Salvador* (Freire 1906). Cattle used the trail on their journey to Salvador's slaughterhouse. Now a paved road, congested with city buses and cars, it crosses one of the most popular districts in the *Bahia* capital, the *Liberdade* (Freedom).

According to the 1950 census, large herds of cattle existed in *Pirapora*, *Juazeiro* and *Bom Jesus da Lapa* numbering over sixty, forty, and twenty thousand animals (Pierson 1972, vol. 2). In the 1950s, *Petrolina* and *Juazeiro* had the third highest number of this animal in *Pernambuco* and *Bahia*'s municipalities integrally located in the valley (Pierson 1972, vol. 2). In the 1960s, it was still a primitive activity (Hilton 1963). The system below (Figure 2.10) illustrates the extensive animal rearing system:

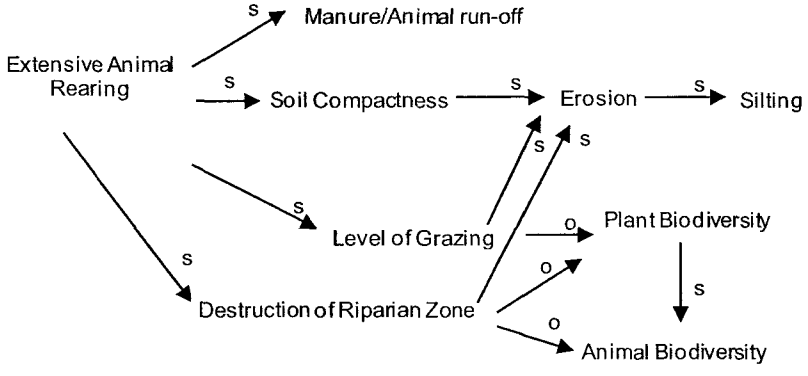

Figure 2.10. Animal Rearing

Extensive animal grazing on riparian zones and in inland areas of *Caatinga* and *Cerrado* biomes has damaged the basin. Indeed, silting is a major problem in the valley (CBHSF 2004). Local populations have deforested because of cattle raising and agriculture leaving the land unprotected (James 1953). In addition, animal grazing has exposed the fragile soil to the forces of erosion. The consequences include soil compactness and reduction of soil porosity, destruction of vegetation, and wild animal species which depends on it for food and habitat (CBHSF 2004). Animals also step over

the river's edges and move sediments into water bodies. They degrade river's spring sites and banks (Neves 2005). Pierson reported that cattle were everywhere nearby water: in islands, river's edges and riparian zones, and in riparian lagoons (Pierson 1972, vol. 2).

Since the 1970s, the expansion of irrigated agriculture has caused a reduction in the area of land devoted to extensive cattle ranching (Araújo 2004, Silva *et al.* 2000, Collins 1995). At the end of 2008, some 7,166,218 cattle and 1,866,271 goats existed in the major ranching zones of the valley: the extreme west and east of *Bahia*, the *São Francisco* zone in *Pernambuco* and north and northwest of *Minas Gerais* (IBGE 2009b). More cattle were in the humid zones of the north of *Minas* and goats in the semi-arid of the middle and lower-middle-SFR of the east of *Bahia* (IBGE 2009b). Meat from bovines is both exported and sold domestically. Meat from goats supplies the regional market (PENSA 2008).

Navigation

The *São Francisco* has a favorable geographic location in relation to the national territory. The water body has both inter and intra-regional roles. It is linked to populations, towns and cities from north and south of Brazil and for that reason, it received the name of *National Unity* and *National Integration* River (Diégues Jr. 1971, Silva1981). It also unites regional states, such as *Minas Gerais*, *Bahia* and *Pernambuco*.

A variety of vessels travelled the SFR's waters – individual canoes (*canoas*), two or more canoe tied together by leather stripes (*ajoujos*), sail boats, ferries, barges, tugboats and rivers steamers. Man power as oarsmen or *remeiros*, wood-stokers on steamers and the entire crew or *vapozeiros* in combination with diesel, wind, and river currents were

the driving forces behind water-based transportation (Halfeld 1860, Burton 1869, Vianna 1893, Bahia Illustrada 1919, Carvalho and Kotscho 1989, Neves 1998, 2006).[34]

Navigation workers have been important for the formation of the local residents' identity and imaginations. At the end of river trips, workers shared information on the geography, history and the legends of the river and region with the younger generations. Navigation workers disseminated news about facts occurring in other reach of the water body, river related traditional knowledge, histories, and legends, such as the use of boats' prow heads (*carrancas*) to repel bad spirits.[35] They spread culture through their songs, knowledge of river's geography, religion and faith (Neves 1998; NGO representative, personal communication, 03 Aug 2006, *Juazeiro*-BA).

In economic and social terms, according to Ab'Sáber (Bisilliat 1986), navigation introduced bigger changes than the expansion that cattle ranching had caused in the basin. It was fundamental to the level of regional commerce by transporting and selling items.[36] Navigation and railroad development fostered a bi-modal transportation system. In Brazil, railway systems linked inland areas of the country as *Pirapora* and *Juazeiro* to the ocean, respectively *Rio de Janeiro* and *Salvador* (Barclay 1917). In the 1940s, Valverde (1944a) described the small regional and commercial port vocation of cities along the middle-*São Francisco* River and the predominance of fluvial transportation. *Pirapora* and *Juazeiro* went beyond its regional function as "port-cities" (cidades-portos) due to their rail link with other municipalities, districts and villages (Valverde 1944b).

Navigation was crucial to the local economy. The different types of vessels carried everything, cargo including salt, people, cattle, mail and money (Rego 1936, Gautherot and Frota 1995). Fishermen and subsistence farmers used small boats to get to

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[34] A *remeiro* used a long pole to move the boat. One side of the pole was used to push against the river's bed and the other against the *remeiro*'s own breast (Vianna 1893).
[35] *Francisco Biquiba dy Lafuente Guarany* made the first prow head (*carranca*) in *Santa Maria da Vitória*, by *Rio Corrente River*, in the SFR Basin, in 1901 (Carvalho and Kotscho 1989). The *Tamandaré* that *Conrado Corrêa de Almeida* owned received the first prow head (Carvalho and Kotscho 1989).
[36] Individual workers' commerce was not allowed in all steamers (Neves 2006).

their work area, to transport their tools or to sell their production (Neves 1998). The local population stopped to see the boats going by or landing in their towns (Pierson 1972, vol. 2).

But, despite its importance, navigation has always been a challenge. Environmentally speaking, deforestation for steamers and other uses, and the load of sediments in the SFR and tributaries it caused, had a large impact. The Figure 2.11 below models the steamers navigation system in the SFR:

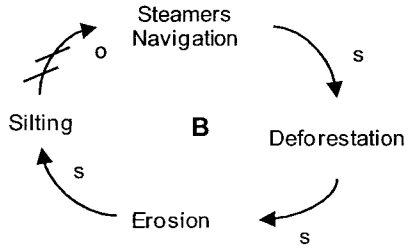

Figure 2.11. Navigation

The *São Francisco* River's depth has decreased overtime and during low-water (Rocha 1983), reducing the possibility of navigation of larger vessels. Boats running aground and bank erosion were frequent. Silting made navigation more difficult. Larger steamers could not find the way during all months of the year because of the conditions of the river (Zarur 1946).

Other problems existed. Steamers required a large crew (SUDENE 1980, Portugal 1952, Gautherot and Frota 1995). The formalization of labor relations augmented costs with salaries, and required formal training and operating licenses (Rocha 1983; Neves 1998, 2006; mechanic-boat driver, PC, 02 Aug 2006, *Juazeiro*-BA).

The construction of roads and the use of vehicles provided other transportation options and increased the level of competition with navigation. Efforts of road construction took place in the national level (Silva and Silva 1991). In 1950, in the 156

municipalities totally located in the valley, 712 trucks and 156 mini-trucks existed, some ninety of them in *Minas Gerais* (Pierson 1972, vol.2). In the late 1950s, navigation and animals were still the major form of transportation for the poor and cargo in the watershed area (IBGE 1960). For instance, barges worked like small travelling stores buying and selling products such as salt, cotton, and sugar-cane cake (Rocha 1983, Gautherot and Frota 1995). Later on, bridges reduced the water-based transportation, such as in the case of the one connecting *Juazeiro* and *Petrolina*.

In the late 1970s, the construction of the *Sobradinho* Dam caused a sharp decline in water-based transportation. The new environment was wide and windy. A wavy reservoir impaired navigation of existing boats (SUDENE 1980). According to Chilcote (1990), fifty-six out of eighty-four motor boats were deactivated and no steamers moved up and down the river. After *Sobradinho*, the navigable zone's division was from *Pirapora* to the beginning of *Sobradinho* Reservoir, from that to its end, and from the end of *Sobradinho* to *Juazeiro* (SUDENE 1980).[37] The changes impaired the transport forty kilometers downstream in cities such as *Juazeiro* and *Petrolina* and the contact with the only larger-scale shipyard of the region located between those mentioned cities. *Juacema* Port, upstream Sobradinho replaced *Juazeiro*'s during that time frame. The construction also cut off an existing navigation improvement plan involving state and federal agencies. The changes inverted the level of importance of the two most important ports of the middle-SFR. *Pirapora* replaced *Juazeiro* as first in rank.

Navigation remained in decline in the middle-SFR. In 1976, navigation in the middle-SFR carried only 32,050 tons of cargo, mainly cement, salt, sugar, rice, manufactured wood products and live animals. The number of passengers using that river transportation system also fell. During 1940s-1960s more than forty thousand people

[37] The creation of the lake had a positive externality: inundating an extension of rocks which had imposed difficulties to navigation before the construction of the reservoir (SUDENE 1980).

used the river annually for transportation on average. But, the number was only a little more than seven thousand in 1977 (SUDENE 1980, CODEVASF *et al.* 1989).

In the lower-SFR, smaller vessels, including sail boats and canoes transported people and up to twenty tons of cargo (SUDENE 1980). In 1980, river cargo transport was not significant (CODEVASF *et al.* 1989).

In 1992 (March 12), the federal government tried to privatize the *São Francisco* Navigation Company – FRANAVE, but no one bought it. The government then closed it. By that time, the federal administration owned 99.7% of it. FRANAVE had 87 vessels of different types. The FRANAVE main office was located in *Pirapora*. *Juazeiro* hosted a FRANAVE office and the shipyard between it and *Petrolina* (Silva *et al.* 2000). The total cargo transport capability was of 200.000 tons per year (Silva *et al.* 2000). But two years later FRANAVE only transported about 58 thousand tons annually (Neves 2006). In January 2007, President Lula terminated the navigation company of the *São Francisco* River, the *Companhia de Navegação do São Francisco* [Decree # 6,020 of 2007].

The *Administração da Hidrovia do São Francisco* – AHSFRA is the entity in charge of the management of the SFR's waterway. It is not an independent body. *Companhia das Docas do Estado do Maranhão*, CODOMAR, manages AHSFRA, replacing the former one from *Bahia*. CODOMAR is a mixed capital enterprise, under the umbrella of a Transport Ministry's agency, the *Departamento Nacional de Infrastrutura de Transporte* – DNIT. The budget for the SFR waterway is included in another agency's budget, DNIT, which is part of Ministry of Transportation (Public employee-CBHSF, PC, 17 May 2007, *Pirapora*-MG). Indeed, as an interviewee affirmed, the major challenge in managing the waterway is the lack of resources. Without such, it is impossible to make the river more navigable by adding navigation aids to the waterway and dredging to remove sand from its bottom to maintain a channel. The bathymetric survey takes about twelve days and should be done constantly since the river is always changing course. But such

maintenance work does not take place very often. By the time of the interview, the last one had taken place about one year earlier (public employee- CBHSF, PC, 17 May 2007, *Pirapora*-MG). AHSFRA now manages the port of *Pirapora*; *Bahia* and *Pernambuco* states are in charge respectively of *Juazeiro* and *Petrolina*'s ports (CBHSF 2004).

All the efforts, including changes in companies' ownership were attempts to save navigation. But in the end, it has not been able to get over the strong competition from roads and vehicles. Water-based transportation was also not capable of overcoming the challenges the river and its degradation imposed.[38]

Deforestation

Deforestation is a problem in the basin which has old roots. In his 1879 trip along the *Velho Chico*, Sampaio (2002) described a rich vegetation of the *Caatinga* biome and the riparian forests. But before the 1930s, a lot of that land cover had already been lost. For example, in his 1926 book, Nash wrote about the end of the forest in the basin. It was seriously burned (Nash 1926).

Various activities have contributed to the issue in the valley: mining; steamship navigation; domestic uses, such as wood for cooking; slash and burn agriculture; and power generation. Therefore, species which used to be common in certain regions of the watershed such as *Juazeiro*, became rare to find even in the city that bears its name. The system below (Figure 2.12) illustrates deforestation in the SFRB:

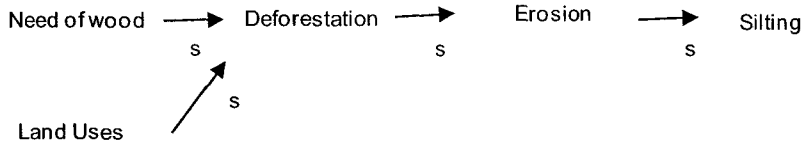

Figure 2.12. Deforestation

[38] Railroad was not able either to compete against roads and vehicles.

Land use/change has contributed to eliminate the traces of forest and other forms of vegetation. Human actions have destroyed semi-deciduous tropical forest that existed in humid zones such as in higher areas (Azevedo 1968, vol. 1). Indeed, deforestation and burning was a common practice of earlier explorers of the valley (Cunha 2005). This problem led the colonial government to prohibit deforestation in the states of *Bahia* and *Pernambuco* in the 18th century (Cunha 2005). Still, the alternative did not solve the issue and worse problems were to come. For example, Valverde (1944) described deforestation of the *Rio das Velhas* River basin as a possible cause of navigation impairment of this SFR's tributary.

Slash and burning deforestation preceded agriculture (Azevedo 1968, vol 1). Burning was a common practice in the entire valley. It was a way of preparing the soil for agriculture and pasture (Engenheiros 195?; Pierson 1972, vol. 2).

River steamers were a major cause of deforestation. Carvalho and Kotscho (1989) mentioned that a round trip from *Pirapora* to *Juazeiro* required 400 m^3 of wood. Since each hectare provided only a hundred cubic meters, each trip contributed to four hectares of deforestation.

Women and children collected wood for their homes (Pierson 1972, vol. 2). In the 1950s, wood used directly or indirectly as vegetable charcoal was the most important fuel in the valley for cooking and to provide heat during the night-time (Pierson 1972, vol. 2). Professional wood collectors, *lenheiros*, supplied local richer homes, wood workers such as boat builders, and steamers. Wood ports, *portos of lenha*, located at riparian areas allowed steamboat stops to refill their fuel reserve (Pierson 1972, vol. 2; Neves 1998). Diesel fed boats from the *Navegação do São Francisco* corporation replaced steamboats only during the 1970s (Neves 2005).

Deforestation has occurred all over the valley. Mining and metal industries have destroyed *Cerrado*'s forests in the upper-SFR and in the middle-SFR. Wood from the basin

is heavily used for steelworks, especially the area of forest that used to be located in the northern part of *Minas Gerais* and south of *Bahia* (IBGE 1960; Pierson 1972, vol. 2; Tupynambá 2001; Neves 2005; Brasil 2009a). "Minas Gerais has many steelworks, which produce about 80% of Brazilian iron foundry... Many of those used vegetal coal as fuel" (Neves 2005:62). In addition to this problem, forestry companies use exotic species such as *Eucalyptus sp* and *Pinus sp* to reforest the area (Neves 2005).

Other patterns of land cover and use have also led to problem, such as road (paved and non-paved) construction. In the 1930's Freise (1938: 378) wrote that, "it annually increases by many hectares the amount of bare and exposed ground without contributing effectively to improvement in transportation." In that period, the automobile was not yet a common method of transportation.

Urban zones and irrigation projects in the basin have cleared tracts of land (Hilton 1963). Riparian cities occupy the place once covered by that vegetation too. Only 3.1% of forest covers the watershed, accounting only for 35.6% of the basin's original forest extent (WRI 2003). Deforestation contributes to the lack of water infiltration in the soil and to erosion, increased run-off during precipitation events. Lack of vegetation in the semi-arid zone removed the soil's ability to retain humidity being more exposed to sunshine (James 1952).

Agriculture and cattle ranching have reduced forest cover (James 1953). African grass has replaced the local vegetation for pasture areas (Neves 2005). Pasture and agriculture have altered *Caatinga* biome's vegetation in the semi-arid region. Burning and deforestation increase the risks of desertification. Only two percent of the *Caatinga* Biome is under integral protection in conservation zones (DNPM 2009). The *Cerrado* in the west of Bahia in the SFR basin is the area with the faster expansion of agricultural activities and consequently deforestation in the last three decades in Brazil. The wood is

also used for charcoal. From 2002 to 2008, the SFRB lost 4.5% of its area of *Cerrado* (Brasil 2009a).

Riverbanks Erosion and Silting

The São Francisco River carries mud, sand and other materials. The system below represents riverbank erosion (Figure 2.13):

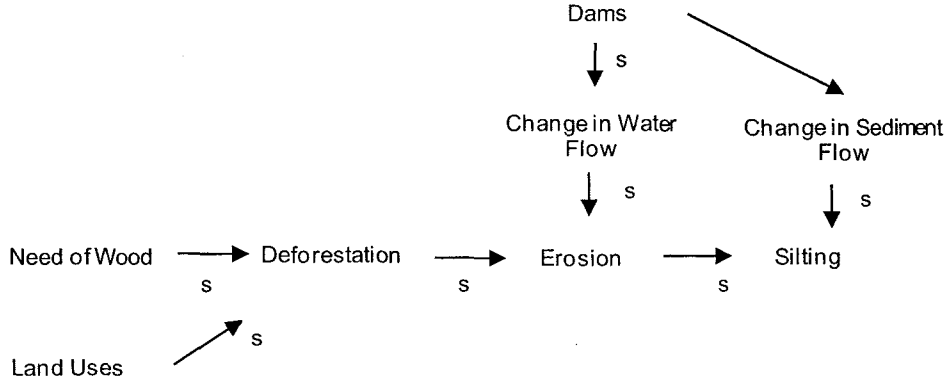

Figure 2.13. Riverbank Erosion

In 1867, Burton (1977) noted that mud walls surrounded the *Velho Chico*. Erosion material from those unprotected ramparts formed mud and sandbanks, whose position changed overtime (Pierson 1972, vol.1, 35). In his 1930s' book, Rocha (1983) predicted that bank erosion would be one of the problems faced by the navigation sector in the *São Francisco* River. Besides the SF, its tributaries, such as *Paraopeba* and *Rio das Velhas* provide large concentration of sediments (Lima *et al.* 2005).

Hydropower infrastructures have affected sediment flow reducing its flux. The *Sobradinho* Dam retains three-fourth of the sediment flow. The amount discharged into the sea is very small (Lima *et al.* 2005). Municipalities' managers ranked silting first amongst environmental problems of the valley. It has been especially noticed in *Minas Gerais* (IBGE 2005). They pointed out the causes of silting as: deforestation and

destruction of riparian vegetation, erosion and landslide of bank's edges into the river, and increasing agricultural as well as animal raising activities (IBGE 2005).

Changes in sediment flow alter river hydraulics and vice versa. Kondolf (1997) shows how sediment starved flow sculpts the landscape, eroding, transporting, and depositing sediment.

Water Quality and other Non-point and Point Sources of Pollution[39]

The system below represents water quality (Figure 2.14):

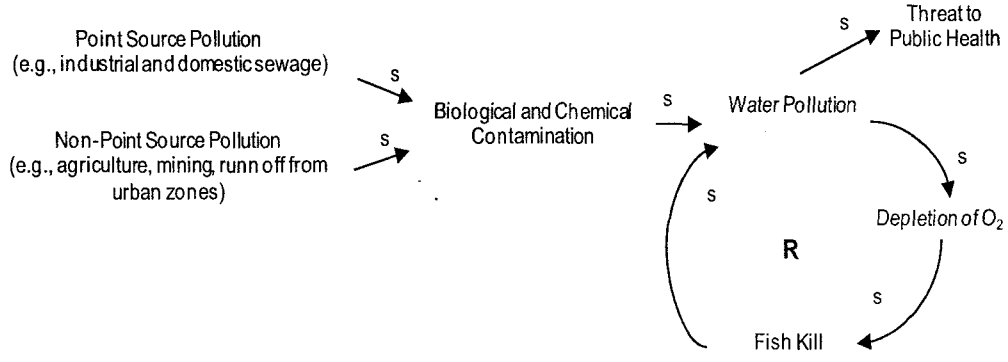

Figure 2.14. Water Quality

Industrial and Domestic Sewage. In a 1944 article, Crist (1944) was amazed that large commercial towns as *Juazeiro* and *Pirapora* did not have water and sewerage systems. As he described,

> The water supply is brought from the river either in kegs carried by donkeys or in five-gallon gasoline tins or large gourds on the heads of water carriers or private citizens. Water for drinking is dipped up along a bank where people wash clothes, bathe, water oxen, and scrub horses, dogs, and donkeys... Drains from houses often empty directly into the street. (Crist 1944:606)

The lack of water and sewage treatment systems, education, and health information made the valley a place vulnerable for the development and transmission of

[39] Non-point source (NPS) or diffuse pollution "originates over a broad area", "is caused by diffuse sources" (CAST, 1992, p.23), and "does not result from a discharge at a specific, single location (such as a single pipe) but generally results from land runoff, precipitation, atmospheric deposition, or percolation" (CAST, 1992, p.23 citing EPA, 1987).

water-related diseases, namely, malaria, diarrhea, typhoid, trachoma, and other parasitic diseases (Pierson 1972, vol. 2). No doubt that the federal government has undertaken measures to eliminate such diseases by the construction of water treatment stations, vaccination campaigns, and insect extermination. For example, the basin of *Rio Verde Pequeno*, a SFR tributary was the first Brazilian site to use DDT (dichlorodiphenyltrichloroethane). This took place in 1947. Today we are aware of the consequence of the use of such products for the general environment. But in the valley, given the knowledge of the time, it served the important purpose of eliminating malaria (Novaes 1989; Pierson 1972, vol. 2).

A report in the early 1970s showed the limited availability of data on source of pollution and on water quality indicators for the SFR and its tributaries. It cited the existence of problems such as the discharge of sewage in SFR's inlets in the upper-SFR such as in the *Paraopeba* River, the release of zinc near *Três Marias* by a metals processing entity, and the lack of fish in *Paraopeba*, *Rio das Velhas* and *São Francisco* River due to water pollution (Development and Resources Corporation 1974b).

In the early 1980s, in the SFR basin, sewage treatment stations existed only in three municipalities: *Remanso*, *Casa Nova*, and *Sento Sé* (MME 1983a). *Petrolina* in *Pernambuco*, and cities and towns in *Minas Gerais* had sewage collection systems, but no treatment (MME 1983a). Still today, the lack of sewage treatment stations in the basin is a problem. Out of 456 municipalities analyzed only thirty-three municipalities treated their sewage in 2000 (CBHSF 2004).

The upper-SFR has been the major source of industrial pollution in the basin. In the 1950s, the industry in the Upper-SFR included: textile, food processing (e.g., milk products), and local products processing such as tanning (IBGE 1960). In early 1980s, industrial sites were still concentrated in the upper-SFR watershed especially *Belo Horizonte* and *Divinopolis* (MME 1983a). It is not different today.

Indeed, regarding sewage not much has been accomplished by the federal government. Investments are low and unequally distributed (e.g., higher coverage in the Southeast). The need is greater than the offer, and low efficiency and productivity take place (Melo 1988, Toneto Júnior and Saiani 2006, Faria *et al.* 2007). The National Health Foundation had helped to improve the service in some municipalities of Brazil. In addition in the early 1970s, the National Sanitation Plan, *Planasa* supported the implementation of centralized state' companies management of water and sanitation systems replacing the existing model that had municipalities in charge (Toneto Júnior and Saiani 2006). But, it led to an unequal increase in the population's access to water and sanitation.[40] Access to water grew faster than to sanitation, urban zones benefited more than rural areas, and major cities, such as *Rio de Janeiro* and *São Paulo* received more attention (Toneto Júnior and Saiani 2006, Melo 1988). In 1986, states and municipalities became in charge of negotiating their own sewage programs (Melo 1988). Planasa, without financial support, ended in 1992. A new phase started and again it shifted towards more decentralization of water and sanitation systems (Toneto Júnior and Saiani 2006; 1988 Constitution, Art. 30, V).

The 2000 census showed that, the national average for sewage coverage system was of 47% (IBGE 2000). But, institutional changes have taken place regarding sanitation. New federal laws have created opportunities for private provision of water and sanitation services via concessions as established in the 1988 Constitution [Law# 8,987 of 1995; Law# 11,079 of 2004; 1988 Constitution, Art.175]. In 2001, the National Water Agency created a program to clean watersheds (*Programa de Despoluição de Bacias Hidrográficas*) – Prodes (ANA 2009b). It is an incentive program providing financial prizes to sewage treatment stations according to the volume of sewage cleansed. In 2007, a sanitation law passed throughout congress [Law# 11, 445 of 2007]. Also in that year,

[40] Access means the opportunity to use. It implies the existence of legal rights, appropriate physical structures, and capabilities to pay.

President Lula da Silva included sanitation in the Growth Acceleration Program (PAC) to provide resources for sanitation works.

Runoff from Urban Zones. The *São Francisco* River and its tributaries drain large urban agglomerations. For example, the *Rio das Velhas* and its inlets, *Arruda*, *Onça*, da *Mata* bring into the *Velho Chico* domestic and industrial pollution plus urban runoff from the metropolitan zone of *Belo Horizonte*. The basin has fourteen municipalities with a population exceeding 100,000 habitants. Ten of them are located in *Minas Gerais* (CBHSF 2004).

Runoff from Mining. The idea of an abundant richness of gold and precious stones has attracted many 'professional' explorers and adventurers to the basin. It was one of the reasons for the initial occupation of the valley (Novaes 1989). Mining is a source of sediment and acid drainage. In *Rio das Velhas*, water pollution with heavy metals has impaired its use even for agriculture (Carvalho and Kotscho 1989). The upper-SFR has been a producer of gold and diamonds in the XVII century (Pierson 1972, vol. 2; Boxer 1962). The upper and middle valley has been a source of crystals around *Xique-Xique* (Silva 1961, Pierson 1972, vol. 2). Copper near *Juazeiro* (*Mina Caraíba* in *Riacho Curaça*) and gypsum near by *Petrolina* (in *Araripina* and *Ouricuri*) are examples of mining products of the lower-middle-SFR. In addition, mining of semi-precious gems such as amethysts was sporadic (Chilcote 1990).

The basin contains a large reserve of mineral resources. The valley produced more than sixty percent of the nation's lead, copper, gold and gypsum. It is responsible for almost the total national amount of chrome, diamond and silver (CODEVASF 1989). Brazil's major iron mining is located in *Minas Gerais*. Some eighty-three percent of the national reserve of zinc is located in the municipalities of *Vazante* and *Paracatu*, in *Minas Gerais*. *Minas Gerais* is the only zinc producer in Brazil. *Bom Jesus da Lapa* in *Bahia* mines brown granite. Carbonate rocks' deposits exist along the SFR in *Salitre* region.

In addition to a grant to exploit a natural resource, mining activity requires an environmental license [Resolution CONAMA # 008 of 1988, Resolution CONAMA # 009 of 1990, Resolution CONAMA # 010 of 1990]. Mining is not allowed in streams and tributaries that serve as a public water supply and in environmentally sensitive areas [Resolution CONAMA # 008 of 1988]. But, all this mining activity entails environmental costs, as described later in *Pirapora* case study.

Agriculture. Fertilizer consumption in Brazil has increased since the late sixties. It jumped from 270,004 Mt in 1961 to 7,682,000 in 2002 (FAO 2006). Fertilizers are used in intensive agriculture, such as in the fruit production *poles* in the Northeast of Brazil. If improperly used (e.g., in amounts more than needed), nutrients contaminate surface and groundwater, soil, air and other environment's elements, including humans.

Other Causes. Other contributions to water pollution that rarely are taken into consideration in the valley are the input from the zones inundated such as for aquaculture and water reservoirs. Those had various forms of land uses, from bare soil to vegetated zones. They also contained cities, fields and cemeteries. In the case of *Itaparica* Dam, more than one hundred individuals died after the flooding of the reservoir due to gastrointestinal disorders from water contamination (Knoch 1992).

Air Pollution. Air pollution is visible such as in the form of deposition from the burning of sugar-cane around *Juazeiro* and *Petrolina* and industrial deposition in *Pirapora* as noted in interviews and observed during a field trip to the area.

A Summary: Water Quality. Regarding drinking water, a Health Ministry resolution [Portaria do Ministério da Saúde# 518 of 2004] requires more monitoring. The Health Ministry oversees the monitoring undertaken by water and sanitation agencies that provide water for public consumption. Such agencies are in charge of providing monthly water quality report to the Health Ministry [Art. 9, IV]. The Articles 11 to 16 of the Regulation# 518 of 2004 establish biological, physical and chemical standards that water

providers need to meet. Samples and tests depend on the type of water body, such as groundwater or surface, size of population supplied and sample site [Art. 18]. Results of tests for color, turbidity, pH and fluorite are reported monthly. Water results for trihalomethanes for surface water should be reported each three months and other parameters each six months [Regulation# 518 of 2004] (Brasil 2005).

The CONAMA Resolution# 357 of 2005 classifies water bodies in the nation according to the quality necessary to support its major use [CONAMA Resolution# 357, Art. 3]. It also regulates effluent discharge into water bodies [Art. 24 to Art. 37].

The quality of the waters of the São Francisco is still a problem. A 2002 analysis (IBGE 2005), based upon qualitative information provided by environmental managers reported that about thirty-eight percent of the municipalities in the SFRB, displayed water pollution due to three major causes: domestic sewage discharge, solid residuals disposal and the use of agro-toxins and fertilizers. The management plan for the valley reported that domestic sewage, agriculture and animal raising, and mining are the major source of water pollution in the basin, in addition to industry and garbage (CBHSF 2004).

The upper-SFR has contributed the highest level of sewage discharge, domestic and industrial, and mining drainage of highly toxic products such as copper and lead, and manganese (MME 1983a, CBHSF 2004, IGAM 2008, ANA 2009b). But, no long term monitoring and records exist for many products (CBHSF 2004).

Summary of Chapter

The *São Francisco* River in its journey to the Atlantic Ocean drains an area of 640,000 square kilometers. The river that springs up as a narrow inlet has an average natural discharge of 2,850 m^3/s at its mouth. Hydropower management is not the only human influence upon this water body. On its way the river receives runoff from mining and urban zones and discharge of domestic and industrial sewage. The effects of

climate change force prioritizing uses and reducing the amount available for local populations. The *Velho Chico* supplies ecosystem services to local, regional and international populations.

This chapter provided the contextual map of the system under investigation. It presents the foundation to my understanding of this river system. The following chapter describes the methodological approach used to tackle the issues enumerated here. Chapter IV shows the new water policy implemented to address the environmental issues described in this chapter.

CHAPTER III

RESEARCH APPROACH: CRITERIA FOR DESIGN AND METHODS

This chapter describes the methodology used for this investigation. It rests upon the Policy Sciences Analytic Framework – PSAF (Lasswell 1971, Clark 2002). The nature of the problem, namely the natural resources related issue; the need for management of common goods for the general well-being of people; and the complexity of the trouble resulting from a human-environment systems relationship are some of the reasons that made me choose to apply this methodology to this research. The Figure 3.1 below illustrates PSAF's three dimensions: problem orientation, context or social process and decision process.

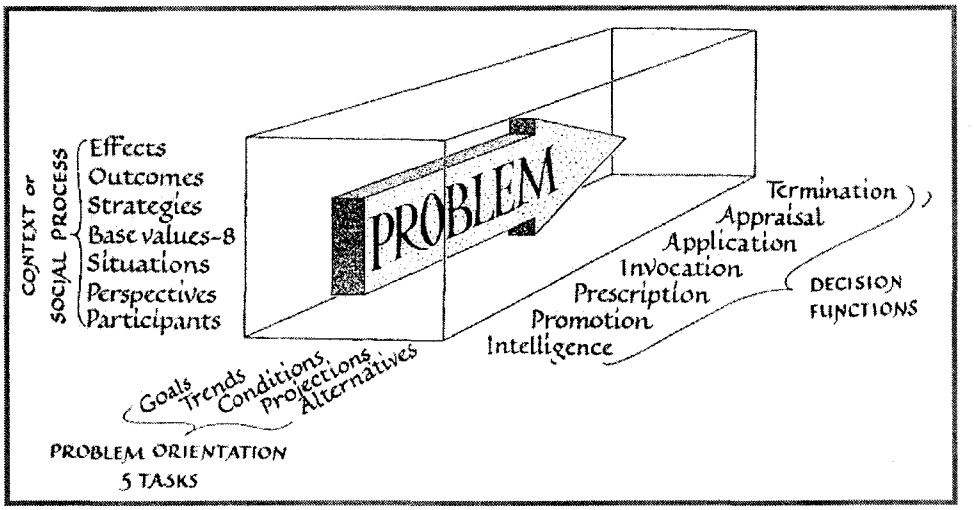

Figure 3.1. Policy Sciences Analytic Framework – PSAF
Source: reprinted, by permission of Yale University Press, from Clark, Tim W., Robert J. Begg, and Kim W. Lowe. "Appendix Fig.1. A Simplified Illustration of the Natural Resource Management and Policy Process." In Tim W Clark, *The Policy Process: A Practical Guide for Natural Resource Professionals*. New Haven, N.Y.: Yale University Press, 2002, 176. Copyright © 2002 by Yale University.

The problem guides policy alternatives. Policy methodologies focus on a problem, and are based upon the whole policy and social processes. Under such approaches, prescriptions are not created apart from the setting where the issue of concern takes place (Lasswell 1970). Lasswell states, "[P]olicy approaches tend toward contextuality in place of fragmentation, and toward a problem-oriented, not problem-blind, orientation" (Lasswell 1970, 6) (Figure 3.1 above).

PSAF, a tool for policy analysis, helped me to describe (map) and analyze (understand) the realities of the *São Francisco* River System. The framework aided me in the evaluation of the changes in the decision process focusing on the implementation of the 'new' prescription, the 1997 Water Policy. This legal instrument altered the existing form of governance, or lack of it, of the water resources of the SFRB with the introduction of, among other tools, the watershed-based committee and water agencies. The analytic model helped me to understand and recommend alternatives to address existing problems.

This chapter also describes the theoretical components and criteria of analysis used in this research: Ecological Sustainability and Ecosystem Approach (EA) (Becker 1996, Pirot *et al.* 2000). I used the indicators of unsustainability to assess the health and integrity of the SFRB ecosystem and the system's capabilities to provide ecosystem services for humans and other species (Millennium Ecosystem Assessment 2005). EA, an alternative used to move a system towards sustainability, is a theoretical construct against which I assessed the present-day form of management of the SFRB's resources, including the nature and degree of public participation.

The first section of this chapter provides the background and context (Section I. Laying the Groundwork for Methods). Section two describes the methods for data collection and analysis (Section II. Methods).

SECTION I. LAYING THE GROUNDWORK FOR METHODS

The Policy Sciences Analytic Framework (PSAF)

Harold Lasswell developed this model in the 1930s (Clark 2002). PSAF aims to improve knowledge of and in policy (Lasswell 1971). The policy sciences inquiry is a problem-solving and value-laden process, which incorporates diverse perspectives, such as of resources' users and managers. The methodology is goal oriented toward solutions that should help satisfy common interests, such as the use of the recommendations provided by this research to the management of the *São Francisco* River to the benefit of society, and not only of few individuals (Clark 2002, Clark *et al.* 2000). In fact, policy sciences application seeks problems' solutions, which are "rational, politically practicable, and justifiable" (Clark 2002:7). Lasswell (1971) suggested that, policy should have stability, being lawful and enforceable, and having a source of support. It should also be comprehensive, fitting different situations and not only attempting to address a moment of crisis (Lasswell 1971). A policy needs to be able to adjust to a changing environment and human systems.

PSAF acknowledges that each observer will investigate the issue from his or her own standpoint. Nevertheless, the methodology enables valid and reliable results, and in doing so, it requires multiple methods to contrast different views and sources of information. The approach also bases itself upon science, verifiable knowledge (Lasswell 1971). Indeed, this study used a research protocol to guide the data collection, organization, and analysis. The data are stored for further reference, if needed. The methodology enabled the investigation of the problem and its trends, past and present forms of management of the water resources of the *Velho Chico* and the assumptions

and objectives which have guided policy. It allowed seeing the system as a whole together with its driving forces and not as a fragmented reality (Clark 2002, Lasswell 1971).

PSAF did not enable providing recommendations that will work for all river related cases. According to Lasswell (1941), lack of knowledge about the institutions and the effects of that on others are barriers to moral achievement. For instance, a project developed in *Brasília*, the capital of Brazil, without enough understanding of the basin's reality, will lead to social and culturally unacceptable results. Each case will require specific recommendations. Policy is a decision made and put into effect (Lasswell 1946). However, the PSAF analyst should recognize that its outcome also depends upon the participants, their interactions and how they interact, and their context, including the natural environment, where the problem is embedded. The lessons learned from this case will enable us to better approach the changing reality of that and other river basin systems.

I applied the PSAF to address different tasks. I identified and focused on the problems affecting the Brazilian river system. I drafted the issue in research pre-fieldwork and the findings of this study supported it: **the unsustainability of past and existing human uses of the *São Francisco* River resources and the effects upon the system's capabilities as a provider of ecosystem services.** I described the social process (participants and their perspectives) and decision functions (*prescription*=establishment of rule, *invocation*=implementation process, and *appraisal*= evaluation) related to the issue of concern. As a Policy Sciences analysis of the complex problem of sustainability of the SFRB, this research ends with, among other things, the evaluation of successes and failures of the 1997 Water Policy (Table 3.1 below) and the lessons learned from this case and from this research experience. The criteria based upon literature review on PSAF.

Table 3.1. A Policy Scientist's Evaluation

	Successes *Criteria:* **Yes** *[rational, politically practicable, ecologically-socially-morally justifiable, comprehensiveness, and stability]*	Failures *Criteria:* **No** *[rational, politically practicable, ecologically-socially-morally justifiable, comprehensiveness, and stability]*
The Social Process	-	-
The Decision Process	-	-
The Policy's Goals	-	-
The Problem	-	-

The Conceptual Framework

Ecological Sustainability. Ecological issues have been under debate since the time of ancient civilizations, such as Greece (Barrett 2001). Nonetheless, only in the mid-80s of the twentieth century has the discussion become widespread around a new concept, sustainable development (SD). In 1987, the World Commission on Environment and Development (WCED) defined SD in its report, Our Common Future, as the development which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:8). The term and its different aspects, such as SD for who and how, have been studied by many (Daly 2002, Orr 2002, Redclift 2002, Harris 2003). Researchers also have challenged the characteristics of conventional economic development and its effects on the environment (Adams and Thomas 1993, Norgaard 1994): asking can this exploitative system continue forever? Due to its choices and behaviors, humanity is already beyond Earth's limits to support growth, beyond the limits of the Earth's carrying capacity in terms of resource use and waste production (Meadows *et al.* 2004). A solution is to reverse that trend and to shift towards a sustainable society. But, what does that mean? According to Becker,

> [a] Sustainable Society: Maintains the integrity of life support systems and ecological processes necessary to support both human and non-human species and provides for equitable access to resources and quality of life among people currently present on the planet and between present and future generations. (Becker 2002)

Hence, ecological sustainability results from the balance among the overlapping interactions of biological, social and economic systems. It is critical to the long-term health and survival of both humans and non-human living beings.[1] Ecological sustainability requires maintaining the integrity of natural systems through the restoration and protection of the health of ecosystems and their elements (Becker 1996). The ecosystems should be able to function and to sustain life support processes, such as water and nutrient cycles. The protection of ecosystem health and integrity means respect for the system's *carrying capacity* and its *resilience to stress*. It also implies recognition of possible *thresholds*, and prevention of future damage [Constanza *et al.* (ed.) 1992]. For example, the International Joint Commission – IJC is restoring the ecological sustainability of the Great Lakes limiting effluent discharge to that ecosystem. Pollution still exists in that system, but its levels have been reduced. The challenges for the IJC include the presence of contamination's fount located outside of the basin, such as long-range atmospheric sources (Becker 1993, 1996; Valiante *et al.* 1997). In the *São Francisco* River case, restoration would mean addressing water pollution and destruction of aquatic populations, creating conditions for "natural" floods to occur, as well as taking action to prevent new threats to its ecological sustainability.

Indicators of Unsustainability. Indicators assess system's conditions and direction in relation to the achievement of management goals (Busch and Trexler 2003b). Appropriate indicators measure where we are and how far we need to go and assess

[1]Ecological sustainability in this case means the preservation of the physical, chemical, and biological characteristics of the life support system and the system's capabilities as a provider of natural goods and services (ecosystem services).

trends and magnitude of changes. Indicators illustrate how the environment is responding to an existing program or lack of it, and permit informed decisions (Shah 2004, Segnestam 1999, Balaton Group 1998). The indicators listed in Table 3.2 below will show if the system's integrity and health exhibit symptoms of stress, if they flag symptoms of impairments of freshwater environments. These indicators reflect harm of fundamental ecological functions necessary for healthy biota and to produce services of particular value to human beings dependent upon the ecosystem.

Table 3.2. Assessing Trends toward or away from Ecosystem Health and/or Ecological Sustainability: Indicators of Damage

Assessing Ecosystem Health and Ecological Sustainability		Per town/city (Present/ Absent)
1	Visible Pollution such as debris	-
2	Restrictions on fish and wildlife consumption	-
3	Tainting of fish and wildlife	-
4	Degradation of fish or wildlife populations	-
5	Fish tumors or other deformities	-
6	Bird or animal (including human) deformities or reproduction problems	-
7	Degradation of benthos	-
8	Need of or restrictions on dredging activities	-
9	Water level (lower/higher) beyond or below the 'normal'	-
10	Eutrophication or undesirable algae	-
11	Exotic species	-
12	Presence of 'dirt' water species (e.g., aquatic vegetation such as *baronesas (Eichornia Crassipes)* that reproduce fast in nutrient rich and calm waters)	-
13	Threatened/Endangered Species	-
14	Restrictions on drinking water consumption, or taste or odor problems	-
15	Beach closings	-
16	Degradation of aesthetics	-
17	Added costs to agriculture or industry	-
18	Degradation of phytoplankton and zooplankton populations	-
19	Loss of fish and wildlife habitat	-
20	Chemical concentration in soil, on water, and in the river bottom's sediments	-
21	Thermal pollution	-
22	Air Pollution	-
23	Water-related diseases in humans	-

Sources: Modified from International Joint Commission (1989), Becker (1996), and Nascimento (2003).

I assembled this list of indicators of negative environmental changes as well as the data presented in Chapter II, VI and VII, from literature search, from personal observations of the river environment and from interviews. I decided not to mention/list the indicators (Table 3.2 above) during my interviews so as to not lead to bias. I let the interviewees, especially the local users, tell me what the changes were from their perspectives and life experiences. Nevertheless, in the first interviews, I introduced three sets of questions: Is the water level the same? Are there fish? Is there anything different? If so, what else? Then, I decided to shift to a simple question to avoid inducing answers. Indeed, the interviewees seemed also to better understand the question: what do you miss? ("*Do que você tem saudade?*").

Interviewees mentioned other indicators which reflected signs of environmental changes. I then added them to the list:

Table 3.2. – *Continued.*

Assessing Ecosystem Health and Ecological Sustainability		Per town/city (Present/ Absent)
24	Existence of bars/restaurants in the sand beach (due to the presence of large sand beach areas)	-
25	Lack of fish jumping at *Pirapora*'s Waterfall	-
26	Lack of fishermen carrying fish (due to the abundance of the fishery) (it might also reflects how the product is now stored/preserved)	-
27	Change in water characteristics: color	-

The twenty-seven indicators above exhibit changes in the natural system with respect to the degree and quality of the ecosystem services provided by the *São Francisco* environment for humans and other species.

Ecosystem Services

According to the Millennium Ecosystem Assessment (2005), "ecosystem services are the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment 2005, sec.1, xiv). In addition, other species and ecosystems aspects depend upon these services for existence. The cited report categorizes the benefits of ecosystem services into four groups: *provisioning services* (e.g., food, fresh water, wood); *regulating services*, for example as flood regulation and water purification, with impacts over other variables such as water quality; *cultural services*, such as spiritual and aesthetical enjoyment; and *supporting services*, which includes nutrient cycling. How can humans reduce the impacts on ecosystems to make a long journey toward sustainability?

Table 3.3. Ecosystem Services

	Note
Supporting	-
▪ Nutrient Cycling	-
▪ Soil Formation	-
▪ Primary Production	-
Provisioning	-
▪ Food	-
▪ Fresh Water	-
▪ Wood and Fiber/Fuel	-
▪ Hydropower	-
▪ Navigation	
Regulating	-
▪ Climate Regulation	-
▪ Flood Regulation	-
▪ Disease Regulation	-
▪ Water Purification	-
Cultural	-
▪ Aesthetic	-
▪ Spiritual	-
▪ Educational	-
▪ Recreational	-

Source: table built from literature review on ecosystem services, which included the Millennium Ecosystem Assessment (2005).

This research uses the Table 3.3 above to document and access the changes on the SFRB's supply, use and impairment of ecosystem services for the period studied. It uncovers if the system is in the right track in its transition to a more sustainable dynamic state of use of its resources and of providing ecosystems services. Given the nature of this

research and my areas of expertise, the emphasis was on the *provisioning* and *cultural* services. Based upon literature review, interviews and field observations, I assessed the changes (Table 3.3 above) comparing the services the SFR system provided in late 1940s-early 1950s and what it provides now (what cannot be provided anymore?).

The management of the SFR system, or lack of it, has impaired uses, but it has also improved and created opportunities for new ones. The interferences have caused both intended and unintended consequences. For the Table 3.4 below, the focal point was to assess how the two major intensive applications of *Velho Chico*'s water (electricity generation and irrigation) have improved or impaired the employment of the limited system's capabilities to provide water and other services. The Table 3.4 below lists and describes the crossed-effects.

Table 3.4. Trade-Off: Improved vs. Impaired Uses

The effects upon these uses → / The effects of these uses ↓	Navigation	Fishing	Public Water supply	Electricity	Flood control	Recreation	Traditional Agriculture	Irrigated Agriculture
Electricity	-	-	-	-	-	-	-	-
Irrigated Agriculture	-	-	-	-	-	-	-	-

Note: Positive Effect (PE) and Negative Effect (NE)

Ecosystem Approach (EA)

In a non-integrated approach, different agencies, often without coordination among them, are in charge of the various aspects of water resources management. This form of governance is usually associated with single uses and objectives. Integrated approaches stand in the opposite side, managing both areas and users, taking into

consideration water quantity and quality of a physical system and its inter-connections. Indeed, integrated models should account for water withdrawal as well as in-stream uses, such as habitat and fishing, meeting water standards requirements to supply and support the various uses. The condition of the hydrologic system depends not only on its components and their state, but also on the feedback among its parts (Hatcher 1981). But initial attempts to employ an integrated/unified form of management and planning of water resources have focused on engineering and hydrologic approaches ignoring or leaving for second plans other aspects, such as environmental considerations (Wengert 1980).

Unified management, differs from other approaches because, it is comprehensive. It takes a holistic view of the basin, and management is not fragmented. Indeed, it is holistic in planning and problem solving (Becker 1996). In addition, it involves human and non-human systems and elements (e.g., geography, hydrology, ecological). It includes an evolving/adaptable structure, respects the integrity of natural system and is sensible to social and institutional systems. The decisions are shared (Harrison 1980).

Many standpoints to achieve ecological sustainability have been theorized and put into practice. Holistic frameworks, such as an ecosystem approach or ecosystem-based management, seek the unified management of natural resources and recognize people's dependence on the environment, understanding the complexity of such systems (Becker 1996). Indeed, as stated below,

> Ecosystem-based management seeks to organize human use of ecosystems in order to strike a balance between benefiting from the natural resources available from an ecosystem's components and processes, while maintaining an ecosystem's ability to provide these at a sustainable level (Pirot *et al.* 2000, 15).

It is a "conceptual paradigm for managing human-environment relationship" inserted in the context of natural systems, in this case, the spatial boundary is the SF river

basin (Becker 1996). The SFRB boundaries surpass jurisdictional boundaries. Besides the influence of policy and politics, "[t]he environmental and economic sustainability of these resources depends to a large degree on what is going on in the larger watershed area" (Perlack *et al.* 2001, 242). For instance, the species composition in the lower-SFR depends on the water quantity and quality which come mostly from upstream. The reduced discharge in the river's mouth is increasing the salinity of the water in the estuary zone as indicated by the presence of sea species that were not common of finding before (Pierson 1972, vol. 1, vol. 2; fisherwoman and fishermen association staff, PC, 7 Jun 2007, Brejo Grande-SE).

An ecosystem approach (EA) to management is based upon ecological principles, such as addressing past damages through the restoration of spoiled ecosystems and preventing future problems, the *precautionary principle*. EA recognizes the importance of the different elements of the system and their interdependence (Christie *et al.* 1986, McCormick 1999, Pirot *et al.* 2000). Human beings are an integral part and influence the system, and human-induced and 'natural' changes will always happen (UNEP 2001-2005). This form of governance acknowledges that the ecosystem has functions, structure, and components (King 1993). An ecosystem approach, similarly to sustainability principles, emphasizes the need to maintain the ecological integrity of natural systems and the importance of natural boundaries over jurisdictional divisions (Mackenzie 1996). The EA recognizes the existence of natural limits in human management and activities (Blatter *et al.* 2001). Human beings are not able to control all processes and forces of Nature.

Participation of relevant stakeholders and legitimacy of the decision-making process, meaning a procedure agreed by the involved parties, are also fundamental

characteristics of ecosystem-based governance (Mackenzie 1996).[2] Public participation means that the views of all parties interested in an issue are included or taken into consideration in the decision process, which embraces decision-making, implementation and oversight (Becker 1993). "To democratize power, then, is to maintain the practice of general participation in the making of influential decisions" (Lasswell 1941, 333). The stakeholders are part of the process that will probably impact the way they live their lives.

Many forms of public participation exist for example, in voting, litigation, letter-writing, working groups, hearing and public meetings. In Brazil, voting is mandatory. The public also participates in more reactive forms, such as demonstrations or hunger strikes (Nascimento 2007). Public and private events can trigger involvement (Rubin 2000).

Participation is "citizen initiated" when citizens bring the issue to public attention. Those individuals are the *catalysts* (Rubin 2000). "Legally required" means an existing statute or regulation mandates it. The 1997 Water Policy mandates this form of involvement. This research assesses new forms of legally required public participation in the context of the SFRB's committee. It also describes other forms of engagement, such as citizen initiated alternatives. According to Lasswell (1971), *effective participants* control the base values necessary to sustain, modify and even tear down the system.

The success of ecosystem-based management depends also on public involvement and cooperative efforts (Pirot *et al.* 2000). The management is participatory and based upon consensus. Public participation support is seen today as a key toward the success of any policy (Rubin 2000). It is important because people will engage, learn together and then foster needed changes in the status quo. Scientific and indigenous knowledge are important parts of an ecosystem approach to management. The approach should create opportunity and invest in training and education of stakeholders to be able to deal with a changing situation (Pirot *et al.* 2000). Public

[2] Stakeholders are organized groups or individuals who must modify a behavior to solve or prevent a problem or who are significantly affected by a decision.

participation is important for learning about people's needs and concerns (Ascher and Healy 1990). It's imperative to uncover people's goals, to be able to arrive at policies and outcomes that are in accordance with people's needs and realities, which will also help to achieve common goods ends and not only those providing private benefits.

Local public and resource users' opinions can increase the level of understanding on the issue of concern. Citizens can provide inputs and perspectives not known to decision-makers (Becker 1993). Public participation avoids or anticipates the occurrence of problems that would be noticed further along into the process of development and implementation of plans and projects and that would be more difficult to be addressed or would require more resources if not uncovered early in the decision process. The involvement of local public and resource users also increases the accountability of the government that will be 'watched.' Trust in a 'transparent' decision-making and implementation processes would be a desired result (Becker 1993).

Nonetheless, the claims in favor of public participation are not shared by all. Critics' arguments relate to the fact that the public should only be involved under certain circumstances; the decision power should be kept within the governmental body; and the transference of power from state to citizens' groups will reduce representativeness in democratic societies, because in this way only the interest of few individuals will be accounted for (Portney 1991, Thomas 1995). Democracy implies representation. Others believe that public participation is unnecessary. They assume that (1) it increases time and costs associated with projects, (2) the public does not have enough information to make wise decisions, or (3) local residents and users are the destroyers from whom the environment needs to be protected (Ascher 1990, Portney 1991, Thomas 1995). On the other hand, Elinor Ostrom has shown that local people can sustainably manage the commons (Ostrom 2008, Berkes *et al.* 2000, Olsson and Folke 2001).

An ecosystem approach requires comprehension of social (e.g., participants, values) and decision (e.g., statutes) processes (Ludwig *et al.* 1994). It also requires a sound understanding of the natural system. "Watersheds comprise highly complex systems that provide a major challenge to those who would attempt to understand and control them" (Perlack *et al.* 2001:242). In federal systems such as Brazil, the government has exerted an important role, and citizens have not had opportunity for much active participation in the management of natural resources. Nevertheless, the 1997 Water Policy altered that order (Santana 1990; 1997 Water Policy, Art. 39).

Under an ecosystem approach, institutional frameworks – laws, regulations and organizations, both implementation and management functions – have to adapt to the condition of the natural system to cope with continuous changes arising from environment, and not the inverse (Becker 1996). Social, environmental, and other conditions must also be integrated into management decisions. Ecosystem management should be flexible and adaptive (Pirot *et al.* 2000).

Institutional and legal frameworks play an important role in ecosystem-based management. "It is argued that a sustainable path depends on developing strong, imaginative, decentralized institutions that are collaborative and foster open participation and deliberation" (Ostermeier 1999:458). Wondolleck and Yaffee (2000) acknowledge the importance of collaboration and partnership among individuals, communities, government and private groups to address environmental and other problems.[3] Among other benefits, collaboration can lead to the solution of a shared problem that could not be addressed by an individual party and can build a sense of community among, people, organization and institutions (Wondolleck and Yaffee 2000). Institutions should foster collaborative efforts to achieve common goals, and should aim

[3] Collaboration occurs when people share the same perspective about objectives and interests. Cooperation takes place when the individuals recognize that although not everybody agrees on the same issue, stakeholders can achieve their different objectives through collective work (Wondolleck and Yaffee 2000).

the achievement of sustainability (Ostermeier 1999). All involved parties are responsible for the maintenance of the accountability of the process. However, agencies should have a strong role assuring that objective (Wondolleck and Yaffee 2000). Institutions should allow, instigate and integrate equal degrees of public participation within the range of stakeholders' groups. Institutional and legal frameworks should also be able to adapt and incorporate changes to better address complex and messy environmental issues (Ostermeier 1999).

Based upon insights gained through literature reviewed and fieldwork, Table 3.5 below is used to illustrate criteria upon which to judge likely effectiveness of a given policy, in this case to assess the new Brazilian system of water resources management using the case of the *São Francisco*. The assessment verifies the ecosystem, the process (learning adaptive, participatory, consensus based), and structure of management (integrative, leadership, accountability). It analyzes the natural conditions and progress of the river ecosystem towards sustainability, the achievement of purposed goals, and the consistency of the new governance arrangement with ecosystem-based management.

Table 3.5. Policy Effectiveness toward Ecosystem-based Management

Criteria to assess Policy Effectiveness toward Ecosystem-based Management	Yes	No
(1) Ecosystem Health and Integrity:		
Indicators: Indicators of unsustainability, change in the provision of ecosystem services, existence of impaired uses		
- Does the system exhibit signs of impairments?	-	-
- Can the system continue providing goods and services for humans and other species?	-	-
(2) Ecosystem-based Governance:		
Effective Implementation		
Indicators: existence of natural over jurisdictional boundaries; presence of holistic management, which takes natural systems and processes into consideration; examples of process and structural adaptation; illustrations of individuals and institutional leadership; examples of scientific-based decisions which takes traditional knowledge into consideration; existence of autonomous and accountable institutions; and example of adaptation due to information generated by the monitoring system		
- Are the organizations compatible with ecosystem-based governance?	-	-
- Is the management adaptable?	-	-
Is the legal framework flexible?	-	-
Is the organizational framework adjustable?	-	-
- Who is in charge and accountable for?	-	-
- Is the new approach knowledge-based (scientific/indigenous)?	-	-
- Does the new initiative create opportunity for capacity building (training/education)?	-	-
- Are there adequate monitoring and evaluation programs and means to incorporate the findings?	-	-
Public Engagement and Participation		
Indicators: participation of a diverse group of stakeholders in the CBHSF; example of decisions which: creates opportunity for public engagement and includes de public, includes local knowledge and expertise; examples of: mobilizations initiated by the public; collaborative initiatives; presence of groups represented that should be involved; example of shared decisions, tasks and costs		
- Does the new approach foster collaboration?	-	-
- Are there alternatives for conflict resolution? Are they consensus based?	-	-
- Is the public (multi-stakeholders) engaged?	-	-
Does the initiative create opportunity for public participation in environmental issues?	-	-
Does the initiative tap the technical and local expertise of the stakeholders?	-	-
Does the initiative use the experience and expertise of the public to develop creative solutions to problems?	-	-
Does the initiative create the opportunity for the public to be heard prior to a decision and thus enable the public to influence a decision?	-	-
Does the initiative avoid or reduce later costs and time delays that often result from not having involved the public?	-	-
Does the initiative build public knowledge of the problem and the decision process?	-	-
Does the initiative increase the credibility and legitimacy of the decision through a visible and accountable decision process which acknowledges the public's concerns?	-	-

Table 3.5. *Continued.*

Criteria to assess Policy Effectiveness toward Ecosystem-based Management	Yes	No
Public Engagement and Participation (*continued*)		
Does the initiative enhance the prospects for successful implementation of the decision by developing some level of commitment by those with a stake in the decision?	-	-
Does the initiative avoid 'worst case' confrontation by serving as a direct means of conflict resolution through prevention or mitigation of undesirable impacts?	-	-
Does the initiative use creative tools and means to attract public attention to environmental issues?	-	-
Does the initiative use approaches to maintain public engagement?	-	-
Is the initiative efficient addressing the issues of concern?	-	-
(3) Institutional Capacity and Policy's Goals:	-	-
Indicators: *use of watershed-based management, employment of long-term management respecting the timeframe of natural processes, examples of actions which have addressed existing problems and have prevented future threats*		
- Are the policy's goals consistent with the aims of ecosystem-based management?	-	-
- Are the policy goals appropriate to address the problems?	-	-
- Is the policy implementation achieving its proposed goals?	-	-

Source: Modified from M. L. Becker (1993, 1996), Nascimento (2003), and Pirot *et al.* (2000).

SECTION II. METHODS

The methods used were those of qualitative field-based empirical research. They included a critical assessment of secondary literature, including quantitative information (e.g., statistical) and data, as well as interviews and field observations. These methods provided comprehensive information of the contextual map of the SFRB. It helped me to understand how the system got to be as it is now. This research presents a cross-cases study of the *São Francisco* system (Yin 1994) carried out in four different phases: I. Scope to specify the problem and map its context; II. Criteria for specification and data collection; III. Data analysis; and IV. Presentation of Results.[4]

Reconnaissance Trips

The SFRB is 640,000 square kilometers divided into four geographical areas: the upper, middle, lower-middle and lower-SFR (Figure 3.2 below). In phase I, prior to my dissertation field research, I visited the *São Francisco* River Basin twice. The first scoping trip took place during summer 2002. Using personal funds, my goal was to establish the first contact with the river environment. Previous to that I only knew it through different forms of media, academic and governmental sources. I sought to start understanding some human and general environment relationships. I wanted to understand the local population's way of living and their survival strategies. I wanted to uncover possible indicators of environmental problems such as sources of water pollution (e.g., raw sewage pipes). I sought to see the magnitude of the change imposed by the

[4] Case study is a research strategy directed to the investigation of an issue as a way of bringing understanding about "individual, organizational, social, and political phenomena" (Yin 1994:2). In relation to a specified problem investigation, this approach is as instrument for policy examination (Yin 1994, Creswell 1998). It has been widely used to report the results of Policy Sciences Analytic Framework inquiries.

construction of the hydropower infrastructures in the basin. I also wanted to assess the existence of possible sources of information such as key people, organizations, libraries and museums, and how to gain access to those resources.

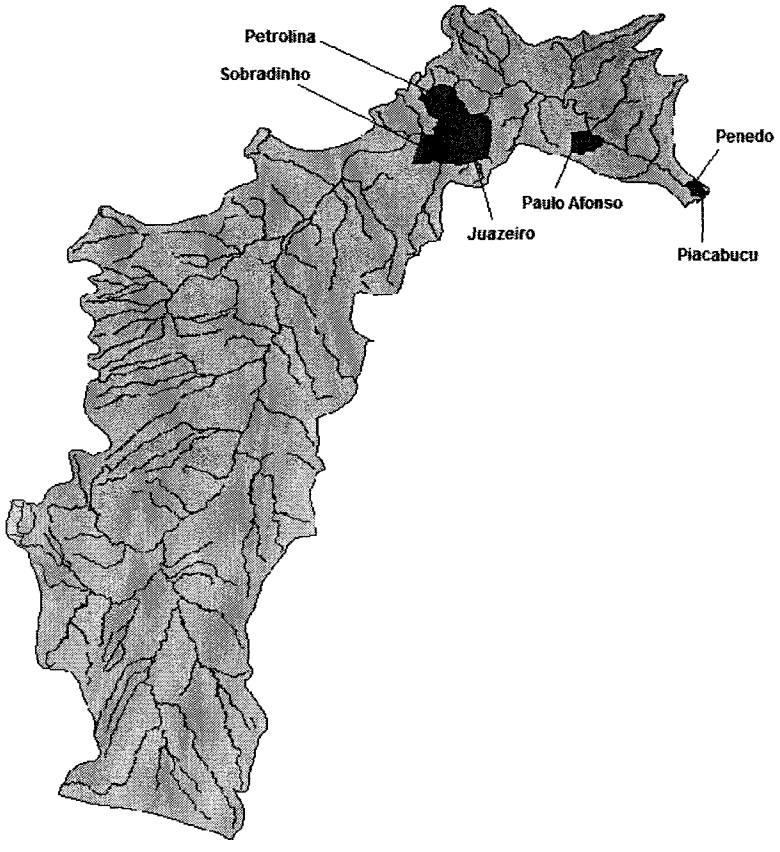

Figure 3.2. SFRB: Reconnaissance Trips – Lower-middle and Lower-SFR
Source: derived from geo-referenced data from ANA Hydroweb visited on 03 September 2009 (ANA 2009).

During this first trip I visited the lower-middle-SFR. I took a bus from my home, the coastal city of *Salvador* to *Juazeiro* also in *Bahia*. It took about seven hours. I visited *Juazeiro*'s twin city, *Petrolina*, located at the other margin of the river, in the state of *Pernambuco*. I engaged in conversations with people from both cities, in popular markets and in boat trips. I also sought to identify libraries and relevant institutions. I then took a bus from *Juazeiro* to a city downstream, *Paulo Afonso*. There, I visited the

hydropower station complex (*Paulo Afonso* I, II, III and IV), the company (Companhia Hidro Elétrica do São Francisco) and its library. I also visited the city's library.

A University of New Hampshire Summer-2004 Teaching Assistantship Fellowship funded the second trip to the basin. It took place during summer 2004. I visited the lower and lower-middle-SFR. The goals were similar to the ones of the first scoping trip: too see the river environment, to find sources of information, which included library visits, and to establish contacts. I also focused on understanding the institutional framework which has been governing the water resources of the SFR system. I took a bus from *Salvador* to the lower-SFR where I visited *Penedo*, *Piacabuçu*, and the river's mouth in *Alagoas* state. I searched for libraries, key people and local government agencies. In *Penedo*, for example, I went to the local office of a federal agency (CODEVASF). I took the bus in *Penedo* to a city upstream, *Paulo Afonso*, to visit other hydropower infrastructures (e.g., *Usina Apolonio Sales-Reservatório de Moxotó* and *Usina Luiz Gonzaga-Reservatório de Itaparica*). I also revisited CHESF's library. I then went to *Petrolina-Juazeiro* from where I left to visit the dam and immense reservoir of Sobradinho also upstream.

During both trips I had the chance to see the countryside, the *Sertão*, and the river environment, cities and towns, popular markets, and to speak with locals, and to go to libraries and governmental agencies. I also visited libraries in my hometown *Salvador* and their online sources (e.g., IBGE, Federal Environmental Institute – IBAMA, *Grupo Ambientalista da Bahia* – Gambá, *Superintendência de Recursos Hídricos* SRH-BA, Federal University of Bahia – UFBA, State agencies in *Centro Administrative da Bahia* – CAB). I had the chance to understand that the life and realities were quite unique in different reaches of the river. These facts made me realize the importance and need of selecting study areas from the four regions, including the medium and upper-SFR which I had not visited in person yet, and that I only knew through bibliographic review and other sources of information.

A University of New Hampshire Summer-2005 Teaching Assistantship Fellowship funded library research in summer 2005. I undertook a literature review. The goal was to further my understanding of different aspects of the river system, such as environmental and socio-economic trends and to conclude the development of my research proposal defended in November of that year.

The Criteria used to Choose Towns and Cities for Case Studies. The choice of the seven municipalities (*Pirapora, Bom Jesus da Lapa, Juazeiro, Petrolina,* Penedo, *Santana do São Francisco* and *Brejo Grande*) resulted from the two first trips, from preparatory work for proposal development, and also from data collection phase, since some decisions were also made in the field. Several criteria motivated the choice of these towns and cities.

Literature review and site visits pointed me towards the challenges of finding existing historic information for some cities in the valley. The data would be necessary to be contrasted against the interviewee's memories and our (theirs and mine) view of the actual reality. I sought existing literature and found out that Donald Pierson and his colleagues had visited several towns and cities in the 1950s for their extensive study of the basin, published in 1972. His research then provided me the background that I needed. Even knowing that Pierson changed the name of some places, I was still able to identify which belonged to a specific group in each region of the river. In his project he also cited information particular to some of the cities that I am studying and the watershed in general. During library research, I also found reports of other researchers who contributed to Pierson's study (e.g., Silva 1961).

The geographical location also influenced my choice. I wanted to include places from different reaches of the river, and "access" issues, which included my personal safety and risk management concerns for a woman traveling by bus and most of the time alone. Another factor was the "apparent" uniqueness regarding the different uses

of the river basin resources, such as the clays used by *Santana do São Francisco*'s residents. *Paulo Afonso* and *Três Marias* are historic sites due to hydropower production in the SFR. Why didn't I choose them? *Paulo Afonso* was a new city. The high inflow of newcomers would impair the identification of local people for a long term assessment of local changes. *Três Marias*, site of the dam of similar name, is in the upper- SFR in a place where the SFR "is one among many rivers" (CODEVASF staff, PC, 24 Apr 2007, Brasília-DF).

The reconnaissance trips helped in understanding the river, basin's towns and cities, and local populations' way of living. It aided the selection of sites for the investigation, sources of data, and key informants' groups.

Data Specification

Change in Criteria for Towns and Cities Selection. In phase II, Data Specification and Collection, (with my tape recorder, questionnaires, laptop and etc.), I left the United States and set up base in my home in *Salvador da Bahia* for data collection. From there, I then traveled back and forth to the basin and to the USA. My data-planning matrix (Table 3.6 below) specified what I needed to know, as well as why and how to answer my research questions.

Table 3.6. Data-planning Matrix

What do I need to know?	Why?	How?
(1)What was the São Francisco River like in 1940s? What were the major social and economic drivers that impacted the river's ecosystem and in what fashion? (2)What are the federal and regional policy goals, and the relevant laws and institutions that have served as tools to regulate the human uses of that system and its elements? How do they relate to each other? How did the laws create need for institutions and institutional arrangements? (3)What are the indicators of unsustainability or of ecosystem functional impairments? How are these addressed by existing policy (ies)?	(1)To learn how the São Francisco River Basin ecosystem has evolved to the present stage of stress. (2)To uncover the policy and institutional arrangements and resource management practices that led the SFR Basin ecosystem to the current state of stress (3)To know what the current level is and if they can be addressed by existing policies	(1)Content analysis of literature: historic records, grey literature; and interviews of locals (2)Content analysis of literature and review of statutes (3)Content analysis of literature, observations of the river and surrounding environment, interview of committee members, and interview of locals
(4)What roles do federal and regional policies and governments currently play in relation to watershed management? How do they relate to each other? Have this changed since the new policy came to being? (5)How do old and new form of management for the human use of the São Francisco River and ecosystem-based approach of management differ? Would an ecosystem-based approach to SFRS be better for its health and integrity than past approaches? (6)To what extent could the new legal and institutional arrangements (SFRB Committee) enable an ecosystem approach to watershed management of the São Francisco River system? What are the leverage points?	(4, 5, 6)To gain knowledge on the new policies and institutional arrangements focusing towards ecosystem-based management. To learn how the new approaches differ from past ones and how they compare to other approaches of ecosystem-based management (e.g., Great Lakes Basin) of human activities to restore sustainability (healthy). To assess the extent to which the new approach could enable a sustainable management to succeed, and if not, what would need to be changed and how. Because the SFR is a national resource. I focused on federal and regional policies	(4, 5, 6) Structured in-depth interview with SFR Committee members; observation of committee meetings; review of literature and statutes.
(7)What roles have citizens or citizens groups being playing in the management of the São Francisco River system? (8)What have been the effects of past management on the environment and on local's life?	(7, 8)To learn the roles citizens have been playing in the management of the SFR Basin system and how the new approach of management might foster a more effective participation and collaboration among diverse users of the system's resources to achieve sustainability goals. To learn what were the change for their life and how affected them.	(7,8)Structured in-depth interview with SFR local users; observation of committee meetings; content analysis of the literature.

Source: Data-Planning matrix model modified from Maxwell (1996:82-83).

When I left the USA for Brazil, I already had selected the list of eight municipalities which I planned to visit: *Pirapora* (upper-SFR), *Bom Jesus da Lapa* (medium-SFR), *Xique Xique* (medium-SFR), the twin cities of *Juazeiro* and *Petrolina* (lower-middle SFR), *Cabrobó* (lower-middle SFR), *Propriá* (lower-SFR) and *Penedo* (lower-SFR). Still, during field work I made some changes. "Empirical research is often a matter of progressively lowering your aspirations... one cannot study everyone everywhere doing everything" (Miles and Huberman 1984:36). I ended up studying seven municipalities.

The news about *Propriá*, the location of the bus station outside of the city, resulted in precarious transportation and the lack of information did not give me a sense of safety. I also excluded *Cabrobó* from the research list because further investigation on the town showed that it is now a municipality of the "*marijuana polygon*" ("*poligono da maconha*") mostly located in the semi-arid region of *Bahia* and *Pernambuco* states. I eliminated Xique Xique because time and other resources would not allow me to visit the area.

I also decided that it would be important to include a more isolated place. I made an assumption that a more isolated city would have a more traditional way of life and a closer link with the environment. In a public hearing in *Brasília* about the inter-basin water transfer project, I heard several times that the lower-SFR had been strongly affected by the cumulative consequences of river changes. I had also observed some of the problems myself in preliminary visits and field trips. I then decided that the isolated community would have to be from that area, to know how the locals were coping with the environmental changes. A meeting with a young fellow from a village, *Brejão dos Negros*, where some inhabitants were self-claiming being descendents of *Quilombos* communities (marooned/escaped slaves' descendants settlements) made me to decide to visit *Brejo Grande*. I made an assumption that, municipalities which were not wealthy, would show more dependence on the *São Francisco* River and its resources for

their immediate needs and local economy. The Figure 3.3 and Table 3.7 below show the places that I visited during field work, in the basin, in addition to Salvador-BA, Aracaju-SE, and Recife-PE outside of the valley.

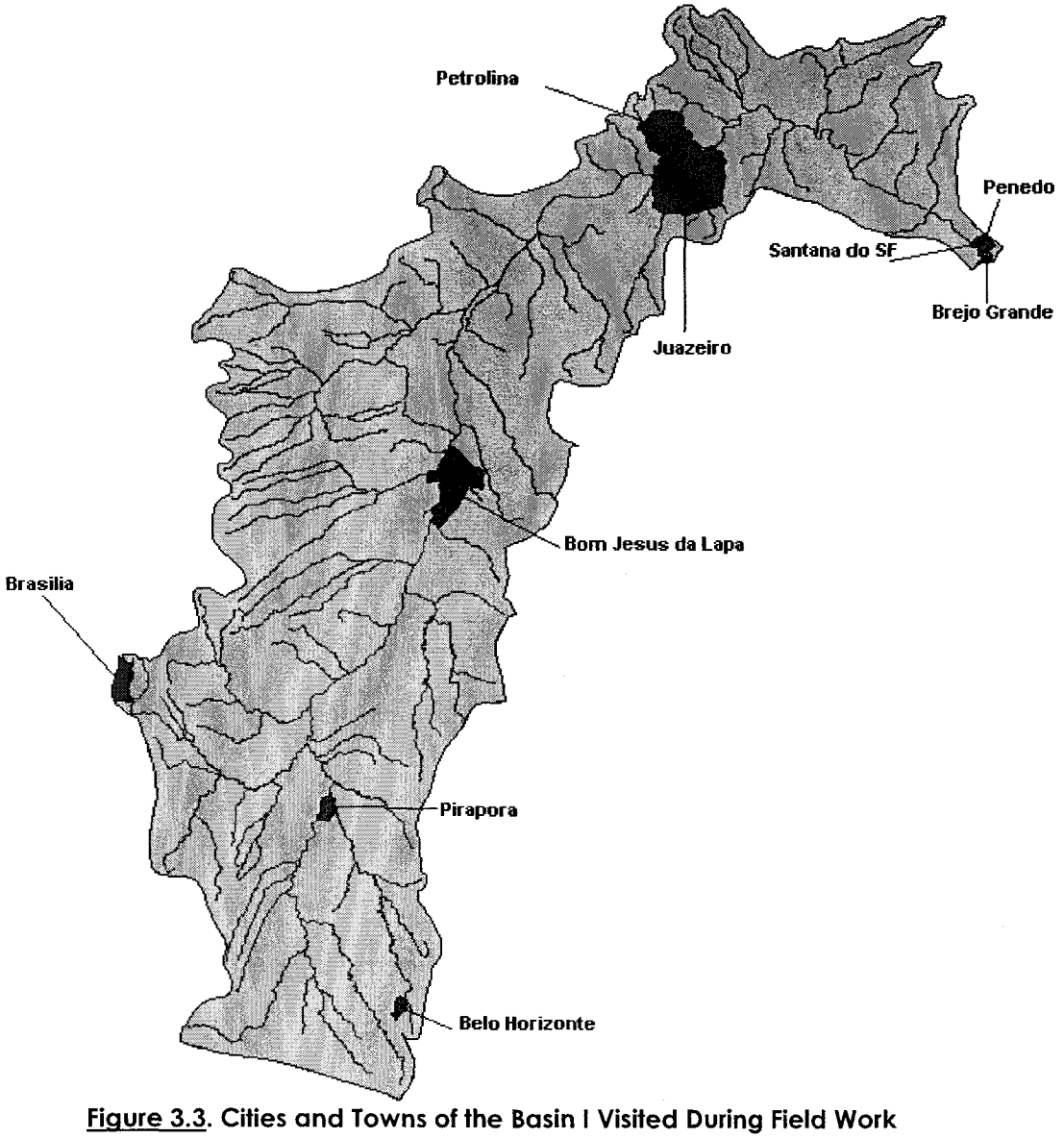

Figure 3.3. Cities and Towns of the Basin I Visited During Field Work
Source: derived from geo-referenced data from ANA Hydroweb visited on 03 September 2009 (ANA 2009).

Table 3.7. Cities and Towns Visited During Field Work besides Salvador

Trip	Local	Date	Tasks Undertaken
1	*Juazeiro* - BA *Petrolina* - PE	July 31 – Aug 5 2006	Library research Identification of key informants Interviews Field observations
2	*Bom Jesus da Lapa* - BA	Aug 18 – 24 2006	Library research Identification of key informants Interviews Field observations
3	*Recife* - PE	Nov 14 – 29 2006	Library research Identification of key informants Interviews
4	*Belo Horizonte* - MG	Dec 05 – 08 2006	CBHSF workshop and plenary Identification of key informants Interview
5	*Penedo* - AL *Santana do São Francisco (Carrapicho)* - SE	Jan 15-21 2007	Library research Identification of key informants Interviews Field observations
6	*Aracaju* - SE	Feb 08-09 2007	Field observation (CBHSF regional meeting) Identification of key informants
7	*Brasília* - DF	Mar 06-16 2007	Library Research Identification of key informants Interview Field Observations (Public Participation against *Transposição*)
8	*Brasília* - DF	Apr 22- May 05 2007	Library Research Identification of key informants Interview
9	*Pirapora* - MG	May 14-20 2007	Library research Identification of Key Informants Interviews Field observations
10	*Belo Horizonte* - MG	May 20-26 2007	Library research Identification of key informants Interviews
11	*Brejo Grande* - SE	Jun 03-08 2007	Library research Identification of key informants Interviews Field observations
12	*Petrolina* - PE *Juazeiro* - BA	Jun 12-16 2007	Library research Identification of key informants Interviews Field observation (CBHSF regional meeting)
13	*Recife* - PE	Jul 02-06 2007	Library research

Data Collection and Analysis

Besides the Data-Planning Matrix (Table 3.6 above), a research protocol (Table 3.8 below) guided data gathering and analysis phases.

Table 3.8. Research Protocol

Data	Data Collection Method	Data Analysis
Secondary – Qualitative and Quantitative	Literature review Why: SFR and selected municipalities related data Where: federal, state and municipality libraries; university libraries; NGOs and private libraries When: cities and towns visited for local interviews and observations; specific trips to library work How: in person, virtual visits	Content analysis to provide data for indicators, to answer research questions-code system, to build case studies
Primary - Qualitative	Observations of river and surroundings environment Why: to assess environmental conditions, to identify key informants Where: municipalities studied When: trips to the valley for this reason and for interviews How: in person	Data contrasted against identified sustainability-ecosystem stress criteria/indicators
Primary - Qualitative	Observations of CBHSF's meetings Why: to see the management in practice and to deal with a great mix of stakeholders, to identify possible key informants Where: different locations chosen due to proximity to *Salvador*, meetings with different agendas since not all equal meetings takes place everywhere in the valley; meetings also chosen due to its category (e.g., technical chamber, consulting chamber, workshop, plenary, election) When: when they took place, followed CBHSF's schedule known through website and CBHSF's contact(e.g., e-mail, telephone) How: in person	Data contrasted against ecosystem-based management theory, criteria for effective public participation, criteria for policy effectiveness
Primary - Qualitative	Open-ended focused interviews with CBHSF members, consultants, etc. Why: to gain knowledge of CBHSF and new form of management of the SFR through CBHSF's members Where: municipality studied, mutually accepted places, including working places and residences When: trips to collect local's views and library research How: key informants based upon the group they represent (government, users, civil society); in person	Data contrasted against sustainability's indicators and code system list, case study format, ecosystem-based management criteria, public participation and for policy effectiveness
Primary - Qualitative	Open-ended focused interviews with local users and/or experts Why: understand changes through their lenses Where: municipalities studied in mutually accepted places, in places I knew informants could be found When: trip specifically with this objective about five days in each reach of the river How: key informants based upon the user's group they officially represent or is a member (religious figure, fishermen, clothes washer, etc.) per city/town and reach of the river; in person (individual, group interview); 1 by phone	Data contrasted against sustainability's indicators and code system list, case study format, ecosystem-based management criteria, public participation and for policy effectiveness

This research included primary and secondary, and qualitative and quantitative data. I aggregated primary data: (1) throughout collection of governmental records; (2) observations of the physical system itself as well as of the *São Francisco* River Committee meetings that I attended; (3) opened-ended focused interviews with SFR committee members, key informants representing different stakeholders groups; and (4) opened-ended focused interviews of key informants within a range of users groups of local and outsiders with knowledge of local's realities.[5] I collected secondary data having completed literature review of theory, historic records and grey literature. I relied upon books, journals, newspapers, documents, Internet sites, research projects, monographs, theses and dissertations, reports of intergovernmental and non-governmental organizations, travel reports, photography, essays and maps. My computer and home personal files store respectively digital and hard copies of documents.

This study meets the validity criteria by using and triangulating different types and sources of information, such as governmental data, academic research, general media information, field data and personal accounts. This research used multiple-methods for data acquisition and collection (observations, interviews and literature review). The data was stored digitally for further reference and the use of a research protocol as a guide to assure objectivity in data collection and analysis procedures assured that this study was verifiable.

Literature Search, Review and Analysis. The search for the relevant literature extended until May 2010. Prior to field work, I had developed most of the theoretical base for the research, the conceptual framework. This study uses the same methodology

[5] "Key *informant interviewing* refers to the practice of making one or more informants a major source of information in one's research" (Wolcott 1999:52). I opted for individual interviews because time issues; it will be more difficult to organize a meeting with different stakeholders from the same group. The second is the level of details; I want in-depth description of the social and economic changes to compose the cases. Governmental reports have represented the views of the bureaucrats and those in the government.

and similar methods used in my master's degree research on the Hudson River entitled Assessing Progress toward Sustainability through Citizen Participation. For that project I had already undertaken a literature review about the meaning, criteria to assess, indicators, and ways to achieve sustainability, such as ecosystem-based management. Nevertheless, this research on the SFR drew more attention to the role of ecosystem services and trade-off among uses. I also had a preliminary draft of the SFR's contextual map, which I have complemented, and I present as Chapter II – Problem Orientation: The *São Francisco* River System. Literature search and review helped me with my interviews and observations because I had some previous understanding of the system I was visiting and about the problems some of those places were facing. I had oriented the problem on its multiple contexts and had some understanding about what I was going to be looking for. I also had identified some possible interviewees, libraries and research sites.

During field work, on some occasions, I contacted the libraries prior to my visit, in other cases, prior contacts were impossible. No way existed to reach them as they had no phone number. Some libraries did not have the material available to the public due to: lack of library space (boxes stored the resources), need of or under restoration processes, and a lack of staff. Nevertheless, this "reality therapy" showed that the 'access' ranged from 'no access at all' to 'complete access'. For example, my second in-person attempt to access the sources at one library in *Recife*, became so successful that, because the library was not opened to the general public, I had individual and exclusive access to everything.

This research included virtual and in-person visits to ministry, federal, state and municipal agencies' libraries; university and other libraries (Table 3.9 below). The in-person visits were necessary because on line access did not exist.

Table 3.9. Libraries Visited

	Library
Federal Agencies and Ministries libraries:	▪ Bibliotecas do Instituto Brasileiro de Geografia e Estatistica – IBGE (*Salvador*, Sudene's building in *Recife*), in person and virtually. ▪ Bibliotecas da Companhia de Desenvolvimento do Vale do *São Francisco* (*Brasília*, *Bom Jesus da Lapa*, in person and virtually. ▪ Escritório do Departamento Nacional de Obras Contra as Secas – DNOCS (Salvador), in person. ▪ Biblioteca da Companhia Hidro Elétrica do *São Francisco* – CHESF (*Paulo Afonso*, *Recife*), in person and virtually. ▪ Biblioteca da Agência Nacional de Águas – ANA, virtually. ▪ Biblioteca da SUDENE (*Recife*), in person.
State Agencies libraries:	▪ Biblioteca da Superintendência de Recursos Hídricos do Estado da *Bahia* – SRH-BA, *Salvador*, in person. ▪ Biblioteca SEI/SEPLANTEC, *Salvador*, in person.
State and Municipal libraries and files:	▪ Biblioteca Pública do Estado da *Bahia*, Salvador, in person ▪ Arquivo Público da *Bahia*, *Salvador, in person* ▪ Biblioteca Pública de *Recife* (*Recife*), in person ▪ Biblioteca de Penedo (*Penedo*), in person ▪ Biblioteca de *Juazeiro* (*Juazeiro*), in person ▪ Biblioteca de *Pirapora* (*Pirapora*), in person ▪ Biblioteca do Instituto Geográfico e Histórico da *Bahia* – IGHB (*Salvador*), in person
Universities libraries:	▪ Universidade Federal do Estado da *Bahia* (*Salvador*), in person ▪ Universidade Federal do Estado de *Pernambuco* (*Recife*), in person ▪ University of New Hampshire (*Durham*), in person and virtually including Inter-library loans (e.g., U.S. Library of Congress)and databases
Other libraries:	▪ Biblioteca do Grupo Ambientalista da Bahia – GAMBÁ (Salvador) ▪ Companhia Hidroelétrica de Minas Gerais – CEMIG (Belo Horizonte) ▪ Sociedade Socio-ambiental do Baixo São Francisco – Canoa de Tolda (Brejo Grande) ▪ Biblioteca de Legislação: Presidencia, Camâra dos Deputados, Senado Federal, virtually

Content analysis of the literature provided insights on the evolution of the problem, history of policy and institutions in charge of the management of the basin. I reviewed the resources in person, and when available through online sources. I made notes, made copies and took pictures. I especially used the two last options in the field to increase my time efficiency. I used the table of indicators (in mind) to look for specific

indicators and also sought for information that could serve as new indicators (Table 3.2). Under a historic perspective, I built the case of each city and for the basin using the format below for the city's case studies (Table 3.10 below). Secondary data were unavailable and primary data were not mentioned during the interview for some categories and municipalities.

I also used the interview code system to locate answers to my research questions. I employed simple quantitative analysis such as statistical calculations, interpretation of results and the use of table and graphics to display information and to develop appropriate trend analysis of quantitative data.

Table 3.10. Cities and Towns: Case Study Structure

Cities and Towns: Case Study Structure
Introduction: how I got there, general description of the river in the area, brief history of the place, name, map (one with all municipalities in the beginning of the chapter), the geography and location regarding river and major cities, area, location of governmental central building regarding sea level, particularities, nearby cities and towns, historic use of river (transportation, fishing, etc.), population in the 1950s, industry, commerce in that period of time
The river environment: climate, biome, precipitation, city and river relationship, meaning of the river, major uses
Causes of environmental degradation: dam, loss of riparian forests, water contamination from land use (mining and domestic and industrial sewage), solid waste, air pollution, other
Agriculture and other related non-point source of pollution: the agricultural products, size of production, animal herds
The Fishery (Fish, fishermen, anglers and fishing regulations) fishermen, tools, license, regulations, monitoring, fish caught, invasive species, fishermen survival strategies
Other ecosystem services: rocks, clay, flood control, hydropower for development, habitat
Water supply: past and present, benefit of the service for local population, the problems
Deforestation (in the municipality and in riparian areas), erosion, silting and navigation (river canal), dam and navigation
Other impaired river uses: cultural values, aesthetic enjoyment: tourism, watch the river, boats, swimming, beach, tourism, religiosity
How developed is the municipality today? census-population today, city income by sector, employment, agriculture census, income distribution, HDI for the municipality in 2000
Conclusions: environmental and social change, alteration in the use of the river's resources

Observations of the River and Surroundings Environment. In this study I included qualitative information gathered throughout my own impressions on the field. The remarks, including pictures, helped me to infer the state of the river and environment. Observations of the river and surrounding environment against identified sustainability/ecosystem stress indicators helped me to assess in what stage the system was at the time of the research. On site, I tried to observe the visible signs of change in ecosystem services and the human uses of riparian zones. I already had some of the knowledge about how the river used to be from my literature review, including photography, and in some cases, from conversations with locals and/or researchers. A list of environmental indicators (in mind) guided my observations (Table 3.2). I stayed about five days in each of the studied sites. I also used that period to identify and interview the participants of this study.

Observations of the SFR Committee Meetings. Observations of the SFR Committee meetings helped me to understand how the new institutional and legal framework, which govern water resources in Brazil, work in practice. For the case of the *Velho Chico*, I tried to observe the way the members interacted, and the issues their discussed. I observed six meetings of the *São Francisco* River Basin Committee – CBHSF: two working groups meetings of technical chambers (*Salvador*, 15 Aug and 26 Sep 2006); two regional meetings (regional chamber of the lower-SFR, *Aracaju*-SE, 08 Feb 2007; and regional chamber of the lower-middle-SFR, *Petrolina*-PE, 15 Jun 2007); one workshop and two combined XI & XII Plenary (*Belo Horizonte*-MG, 05-07 Dec 2006); and one election meeting to choose municipalities' representative for the state of *Bahia* for the 2007-10 period (*Salvador*-BA, 09 Jul 2007). The election was the last meeting I observed. That meeting was my last in-person contact with the watershed committee. But, I have sent few e-mail requests since then. In this dissertation I present a sample of the views of the

members of the 2005-2007, since my personal communications took place before the 2007 elected members took charge.

As an average citizen, I would have had difficulties keeping up with the meetings. I learned about them because I was looking for them in the website. I sent an e-mail requesting access and I called the committee office in *Salvador*. The working groups had few ads to the public. It was basically announced to members, using e-mail communication. Other meetings were generally poorly publicized for the general public. Advertisements posted on the CBHSF website, flyers in state (e.g., SRH-BA) and federal agencies (e.g., CODEVASF-PE) revealed that the committee in practice was a 'closed' representative group. I obtained the schedule for the meetings through personal communication and internet access. I gained admittance to the meeting (e.g., regional and technical chamber meetings, election meeting, workshop, plenary) upon request because of my student status. The only meeting I did not have access to were those of the Board of Directors.

I used 'access' as the major criteria in choosing the sections to attend: location, proximity of the meeting to the city of *Salvador* or where I was doing fieldwork. The working group meeting was held in *Salvador*, which was where the secretariat was located. The secretariat is now in *Maceió, Alagoas*.[6] I also went to meetings in different locations to observe a greater mix of stakeholders. I observed different 'types' of meetings (e.g., working group, plenary, regional meetings, and election assembly).

I recorded some meetings and/or took notes in the "Observation Form". The observations took place (*Salvador, Aracaju, Petrolina, Belo Horizonte*) from Aug 2006 to Jul 2007. By then, the elected members for 2005-2007 had been working for about a year. I applied a content analysis of the information from the meetings and literature on

[6] The secretariat is moving to *Belo Horizonte*. It will be located at the delegator watershed agency, *Peixe Vivo*.

the SFRB Committee against the criteria and indicators to access policy effectiveness toward ecosystem-based management (Table 3.5).

Structured Interviews. According to Miles and Huberman (1994) and Creswell (1998), sampling in qualitative study can be purposive and driven by the questions that the researcher seeks to answer (in my case, Table 3.6. Data-planning Matrix). A combination of "purposeful sampling strategies" seemed appropriate to deal with the diversity and difficulties of this research (Miles and Huberman 1994). As described in the following sections, I used "snowball or chain" (third party recommendation) sampling and references in the literature to select participants of the SFRB Committee. Their location, residence in the cities I was going to visit to interview local people was also a plus. I had a list of them, from the committee, which included the place where I could find them. I also used the "snowball" approach to find key local people. Peers also recommended themselves and/or group representatives. I used the "random purposeful" alternative when arriving in sites where I knew that a user group's members would be doing his/her activities. For example, in *Pirapora* I went to the area used by clothes washers.

Interviews with SFR Committee members contributed to the understanding of the council under its members' perspectives: roles, objectives, capabilities of the new framework to deal with the river basin's problems, challenges, etc. Interviews with local users were the major effort of this research. These local's appraisals provided means to identify their perception of ecological change in that river system, and to learn how these changes have affected their lives and livelihoods and the extent to which they are involved or have access to the decision process. They helped me to reveal locals' proposed solutions for the environmental problems of the basin.

It was difficult to divide people into two groups as planned since some interviewees were both, a local user/expert and a CBHSF's member. For those, I then selected questions from both questionnaires. (For copy of the Institutional Review Board Approval and extensions, and English and Portuguese verbal consent forms and questioners used for interviews, please see Appendix A – IRB Approval, Appendix B1 and B2 – Informed Consent Form, Appendix C1 and C2 – Focused Interview Form: SFRB Committee Members, and Appendix D1 and D2 – Focused Interview Form: Ecological Changes under the View of Local Population of the SFRB, and Appendix E1 and E2 for Observation Forms). Interviews took place from Aug 2006 to Jul 2007, and lasted from about 30 and 45 minutes of length. I recorded and made notes. Portuguese was the language of the interviews and of the transcriptions. As a rule, I translated all the quotations (from interviews and literature when not originally in English). Exceptions are noted.

For the local residents, I sought mainly representatives of stakeholder (target) groups such as fishermen, small farmers, boat workers, clothes washers, water treatment plant workers, environmentalists, and so on. They would give me, in my point of view, a broad view of the issues due to their experience in group representation.[7] I selected target group representatives throughout literature review and third party identification. In one city, a local government agency employee provided a list of possible organizations, which included some that I had already identified as possible alternatives for interview. When I did not find organizations' representatives, I randomly identified members from those stakeholders groups in places where I possibly could find them (e.g., in the river, popular markets, and churches) and followed leads from third parties inquired. Long-time taxi drivers provided some leads. I also used the phone book and long walks to search for associations in town. I also focused on elderly residents. Most of them, I had not

[7] According to Paula *et al.* (2006), oral traditions are collective and only survive when they represent the group's worldviews and the groups' members accept them.

contacted previously, since many of them allowed the interview to happen at our first meeting. Most of them were very approachable. I rarely was turned down by local residents.

Regarding the SFRB committee members, I avoided interviewing them during the trips used to observe the meetings. I did not want to interfere with the process, since many individuals only met during those events. I had a CBHSF's members list provided by the CBHSF. I chose the council members from personal observations of the meetings, literature review, third party identification and referrals. I visited the ones living/working on the towns and cities that I visited to observe, to do library research or to interview the local residents. They were also chosen to represent different users' groups. Most of the time, I contacted some of them previously by phone and/or e-mail to schedule time and location. Some members are connected to the CBHSF for more than one electoral cycle. Committee members interviewed were: official governmental representative, proxies, working groups' members and consultants. I interviewed members, proxies and consultants participants of the 2005-2007 management, but some of them had been involved in previous stages.

The Interviewees. I made 76 interviews, predominantly individual personal communications (Table 3.11 Participants below).[8] Only four of them were group interviews. On one occasion, the interview occurred via phone. I interviewed retired people, actual workers, and still working retired individuals. The interviewees main professions included: artists; clothes washers; boat navigation staff members such as mechanics, sailors and pilots; subsistence and market oriented farmers; rural workers, rural worker association's representatives; fishermen (fish, crabs, shrimp); fisherman association's representatives; researchers; professors; other university graduates; head of

[8] I only used 75 interviews because I needed to cancel one. The number seems low in relation to the size of the watershed. But, this research sought interviewees who could provide the shared view of groups and not perspectives from an individual's point of view.

NGOs; municipal, state and federal agencies staff members; gatherers; honey producers; religious figures; and popular market salespeople. Some of them fall into more than one category. Most of them have had close link with the river: in their work life (e.g., NGO representative, Catholic Church, and school/university), culturally (e.g., music, dance and poems), geographically (e.g., 70% of PE falls within the basin) (Sewage-CBHSF, PC, 17 Nov 2006, *Recife*-PE). Regarding the locals, few are members of the CBHSF and of its working groups. Most of the ones who participated in the CBHSF had previous involvement in public participation (10 out of 16), even regarding water resources issues. Few interviewees outside of the SFRB committee were engaged in public participation too (e.g., fishermen associations, rural workers association, church movements).

Table 3.11. Participant Table

Local of Interview	Professions
Juazeiro/Petrolina	Clothes washer
Juazeiro/Petrolina	Clothes washer
Juazeiro/Petrolina	Public employee – agriculture
Juazeiro/Petrolina	Boat mechanic and boat man
Juazeiro/Petrolina	Public employee – water
Juazeiro/Petrolina	NGO representative – water and environment
Juazeiro/Petrolina	Land workers association
Juazeiro/Petrolina	Fishermen association
Juazeiro/Petrolina	NGO Representative
Juazeiro/Petrolina	Public employee – irrigation
Juazeiro/Petrolina	NGO member and local public government staff
Juazeiro/Petrolina	Small-scale farmer working with irrigated agriculture
Juazeiro/Petrolina	Water treatment station staff
Bom Jesus da Lapa	Market oriented small farmer and commerce men
Bom Jesus da Lapa	Public employee – land
Bom Jesus da Lapa	Ex-clothes washer
Bom Jesus da Lapa	Boat man
Bom Jesus da Lapa	Fishermen and fisherwomen
Bom Jesus da Lapa	NGO representative – rural workers-small farmers-gather
Bom Jesus da Lapa	Public employee – water
Recife	Public employee – indigenous group
Recife	Public employee – sewage
Recife	Public employee – Northeast
Recife	NGO representative – indigenous people
Recife	Public employee – fishing
Barra- via phone	Religious figure

Table 3.11. *Continued.*

Local of Interview	Professions
Penedo/ Carrapicho	*Boat man*
Penedo/Carrapicho	Popular market seller
Penedo/ Carrapicho	Ex-rice farmer
Penedo/ Carrapicho	Fisherman
Penedo/ Carrapicho	Fisherman
Penedo/ Carrapicho	Public employees – water
Penedo/ Carrapicho	Clothes washer
Penedo/ Carrapicho	Fisherman
Penedo/ Carrapicho	Small-scale farmer
Penedo/ Carrapicho	Fisherman
Penedo/ Carrapicho	Small-scale farmer/commerce man
Penedo/ Carrapicho	Clothes washer and public employee
Penedo/ Carrapicho	Fishermen and potter
Penedo/ Carrapicho	Small-scale farmer
Brasília	Public employee – land
Brasília	Public employee – basin resident
Pirapora	NGO representative – environment
Pirapora	Steamer staff
Pirapora	Public employee – navigation
Pirapora	Historian
Pirapora	Clothes washer
Pirapora	Public employee – water
Pirapora	Fisherman
Pirapora	Cloth washer
Pirapora	Ex-steamer staff
Pirapora	Ex-steamer staff
Pirapora	Fisherman
Pirapora	Fisherman
Pirapora	Ex-steamer staff
Belo Horizonte	Indigenous People
Belo Horizonte	Public employee – hydropower
Belo Horizonte	Researcher – navigation
Belo Horizonte	NGO – water and etc
Belo Horizonte	Manager - industry
Brejo Grande	*Rice plantation worker*
Brejo Grande	Retired boat worker
Brejo Grande	Fisherwoman and fishermen
Brejo Grande	Cloth and dish washer
Brejo Grande	Water treatment plant – staff
Brejo Grande	Religious figure
Brejo Grande	Non-governmental organization – environment and river
Brejo Grande	Public employee – governmental body
Brejo Grande	Water treatment station – staff
Brejo Grande	Local user – crabs collector
Brejo Grande	NGO – fishermen
Brejo Grande	Fisherwoman
Brejo Grande	Fisherwoman and fisherman's wife
Salvador	CBHSF consultant
Salvador	Public employee – environment

Interviewees lived in places such as *Brasília*, *Belo Horizonte*, *Pirapora*, *Barra*, *Juazeiro*, *Salvador*, *Bom Jesus da Lapa*, *Petrolina*, *Penedo*, *Recife*, *Santana do São Francisco* and *Brejo Grande*.[9] Many of them have known the *Velho Chico* for their entire life. The period of time those interviewees have known the *São Francisco* River falls into the interval of a couple years to eighty-three years, with average around forty-eight years. Most of the interviewees were born in cities of the basin or in towns/districts under the jurisdiction of valley's cities [e.g., *Casa Nova* (BA), *Juazeiro* (BA), *Remanso* (BA), *Pirapora* (MG), *São Romão* (MG), *Sento Sé* (BA), *Xique-Xique* (BA), *Bom Jesus da Lapa* (BA), *Brejo Grande* (SE) and *Penedo* (AL)].

Interviewees' and family members' memories included meanings and uses of the river by multiple generations. Grandparents, parents, uncles and aunts have lived in riparian regions as fishermen, small farmers and share-croppers, growing a more diverse set of products in their small extension of riparian and dry land (*roça*). Their accounts included memories of members of older generations cutting wood for steamships and transporting it to riparian zones by donkey. Interviewees were also sons and grandsons of fishermen who fed their families catching fish and shrimp, and collecting crabs in the estuary of the lower-SFR. Transportation services have provided direct or indirect means of survival for steamship staffs and other nature of boats' workers. The example of the latter included a daughter of a mail man who depended on the river for transportation and a businessperson's son exporting leather, skins and *carnauba* wax originally from the *Caatinga* through transactions dealt in the *Juazeiro-Petrolina* port.

The recollections of older generations of the past sixty-years depicted a healthier, a deeper, and a fish-rich and shrimp-stocked river than it is today. It was able to help them survive even during difficult times. Despite the unpredictability of droughts and rains, the river was more predictable, or they knew better how to 'understand' it, then

[9] In *Recife*, *Pernambuco* state capital, I interviewed two groups of people: specialists in public agencies and/or CBHSF's members.

people today. In the course of this research, the river is personified many times, as described by a *Pirapora*'s fisherman, "my parents fished and grew crops with *Chico*" (Fishermen association's staff, PC, 15 May 2007, *Pirapora*-MG). The river is, at the same time, father and god, as represented by the frequent real action of a canoe man requesting the river's blessings, described by Guimarães Rosa (1983, 79), in one of his fictional literary works, *Grande Sertão: Veredas*. Interviewees and family members' memories portray the SFR as a multiple-use resource. They especially mentioned its history for transportation, fishing, and water supply for people and small-scale agriculture. They have observed the environmental degradation of the river, and the existence of impaired uses throughout time (e.g., navigation, fishing, and lack of flooding of lagoons which allowed fish growth and rice fields).

Exploring the Interviews. Miles and Huberman (1994:10), "define *analysis* as consisting of three concurrent flows of activity: data reduction, data display, and conclusion drawing/verification." During my data reduction phase, I manually analyzed my qualitative data from the interviews (data from 75 interviews, then from a 117-page long table) based upon an explanation-building technique to answer my major research questions. The process involved reading the interviews several times to understand the views and opinions of the local residents, CBHSF's members, and other people linked to it. I applied a thematic approach to code (Table 3.12 below) using words from the questions present on my two open-ended research questionnaires.

According to Yin (1994, 98), it is important to "maintain a chain of evidence." In this investigation, I used the general research question (p.5) and sub-questions (Table 3.6) to build the two questionnaires (Appendix C1 and C2, Appendix D1 and D2).

Table 3.12. Coding System

Questionnaire: Local Populations	Questionnaire: CBHSF
Interviewee history	Interviewee role
River importance	Interviewee History of Involvement
River meanings	Holistic Idea
River uses	Before CBHSF
Uses parents	Now
Uses grandparents	How (got involved)
Spoke (how older generations spoke about the river?)	Besides SFR/Public participation
Environmental change	River meaning
Change/miss/*saudade*	River should be used
Causes	CBHSF implementation
Social change	CBHSF timeline
Economic change	CBHSF goals
General Changes	CBHSF role
Trade-off	CBHSF should do
Survival strategies	CBHSF actions
Interactions	CBHSF importance
WTP	CBHSF can impact
CVSF/SUVALE/CODEVASF	CBHSF has impacted
Politics	CBHSF what make work
Gov right	CBHSF challenges
Gov wrong	CBHSF priorities
People right	*Transposição*
People wrong	Change anything ~~CBHSF~~/ committees
Should be done	Future CBHSF
Citizen participation	Involved/missing
Governor	Role government plays
Revitalization	Role concern citizen
Transposição	Change in participation
CBHSF	Effective pp
Add (anything else to add?)	Committee-committee
-	proxy-titular relationship
-	Need to be done
-	Revitalization
-	Election
-	Importance of Gov
-	Add (anything else to add?)
-	CNRH

The answers for the interviews raised new issues (open approach) (trade-off among uses; priorities of CBHSF; future of CBHSF; views of CBHSF; committee-committee relationship; proxy-titular relationship), which also prompted questions for new interviews (e.g., what do you miss? [*Do que você tem saudade*?]; who makes the CBHSF function? [Quem faz o CBHSF funcionar?]; from where comes CBHSF's strengths? [De onde vem a

força do CBHSF?]; what should CBHSF's priorities be? [Quais devem ser as prioridades do CBHSF?]; do you perceive that the CBHSF has already caused changes? [O CBHSF ja' causou mudançcas?]; what about the future of CBHSF? [Qual o futuro do CBHSF?]). I also compared the CBHSF members' interviews to arrive on their common views of the committee. Summary tables resulted from the data reduction phase and aided the visualization of relevant information. Some of them are included in this dissertation.

Since this research also assessed public participation, it was important to highlight that many locals initially refused to answer the question evaluating governmental work (What is the government doing right and wrong?) I have three hypotheses for that fact: (1) the military dictatorship period seems to have left some open scars, (2) the influence of local politicians, and (3) the fear about losing the current assistance benefits provided by the government of President Lula da Silva. I need to explicitly make sure that they knew that I did not have any political association. Another rejected question (Would you change anything in the CBHSF?) about the CBHSF needed to be modified. Then, I reformulated the question and went from specific to general: Would you change anything in committees' structure? Additional information was welcomed and included as data during the data analysis phase ("content analysis").

I used cross-case analysis to assess and to link the causes and consequences of environmental changes to the socio-economic sacrifices for each site studied (Table 3.13 below) (Yin 1994). I then drew my conclusions from it also based upon the knowledge of the literature. The shift from the initially planned single to a multiple-case approach was important to show the changes and their effects on different reaches and communities of the river.

Table 3.13 Cross-case Analysis

	Pirapora	*Bom Jesus da Lapa*	*Juazeiro*	*Petrolina*	*Penedo*	*Santana do São Francisco*	*Brejo Grande*
Causes of Environmental Change	-	-	-	-	-	-	-
Environmental Consequences	-	-	-	-	-	-	-
Led to Socio-economic Consequences	-	-	-	-	-	-	-

Lessons Learned from Data Collection. The researcher sees oneself tempted and sometimes obligated to abandon previously defined methods. According to the literature on field research, fieldwork or "reality therapy" will probably demand method adjustments. I constantly struggled between what questions to ask. I could have asked all my interviewees all the questions from my focused interview forms, to end up with a more quantifiable and analogous type of answer, such as data on how many years of experience each interviewee had worked along the river. Nevertheless, I also wanted to dig into the areas of expertise of each individual, such as asking fishing related questions to fishermen and water quality characteristics to water treatment plant managers. In fact, "In deciding on the structure of interviews, the researcher chooses between providing sufficient control and structure so respondents produce comparable data, and sufficient lack of structure to allow the interviewee to construct their own subjective responses" (Rowbotham 2004, 226). The two open-ended research structures basically guided the interviews, but not surprisingly, I asked additional questions for clarification within interviewees' area of expertise. I sought people interested to talk about the river and/or its management.

This research has roots in ethnographic studies. I consider each one of the interviews as an ethnographic investigation. I let my research subjects tell their story within their environment and culture. I tried to enter the interviewee's world, and looked for particularities in how the interviewees and the group which their represent have been

interacting with the environment and how environmental and consequently other changes have affected that relationship. But, I do not think that I spent enough time with each one of them in their own environment to do such a type of investigation as beautifully done by Kottak (1999) in his account of social change in a Brazilian village.

Presentation of Results

A dissertation in the form of a case study and a picture profile are the final products of this doctoral research. The expected outcome is to map the system under investigation in its different contexts, understand its social and decision process and how such processes have influenced the environmental conditions of the SFR system.

CHAPTER IV

WATER RESOURCES AND THEIR GOVERNANCE

> Fresh water ... limits take many different forms. In some watersheds the limits are seasonal, dependent on the ability to store water through dry periods. In other places limits are determined by groundwater recharge rates, or snowmelt rates, or the water-storing capacity of forest soils. Since water is not only a source but also a sink, its uses may also be limited by the degree to which it has been polluted upstream or underground. (Meadows *et al.* 2004:67)

In addition to the statement above, freshwater limits are also associated with political variables: politics and policy.[1] The purpose of this chapter is to describe the major frameworks which have governed the water resources of the *National Unity* River in the twentieth and present centuries. This chapter addresses the following research question: **how does the new approach differ from old forms of water resources governance?** It shows that this South American nation has stepped forward in relation to water laws and policy as well as how it has lagged regarding implementation. It focuses on their relevance to water resources and the *São Francisco* River. It was based upon a literature review, on interviews with the SFRB Committee members and other participants and on observation of their meetings. Interviews with local users also provided insights and leads.

Brazil is a democratic federal republic with power shared among the three branches of government – Executive, Legislative, and Judiciary – and the units of federation (Federal District and states). The SFR is a national resource. It shares no borders with any other country. It is a federal river, managed by the Union, because it crosses

[1] Limits are also dependent upon the use of technology.

more than one state. The management of the *Velho Chico* system is complicated, jurisdictionally speaking. Its tributaries are state and federal rivers. Besides, Brazilian states have jurisdiction over groundwater resources.[2] Since the 1930s, government agencies have in addition to drought control, managed water resources in Brazil focusing on hydropower generation, even though the 1934 Water Code had suggested multiple employments. The electric sector became the major water user. In practice it took over the role of planner and regulator of the basin's hydro resources.

In 2008, the *São Francisco* River system's governance fell in different phases of the *decision process* (Clark 2002).[3] Besides the 1934 Water Code, still a valid instrument, several policies governed or influenced the human use of the water of that ecosystem. They ranged from *prescription* to *termination*. Besides, new ideas had been in the decision-making table, and information had been gathered and discussed by society in general, such as the controversial project that was becoming reality and in the future will transfer SFR's waters to *Pernambuco* and other states of the northeast. Then, the system was under *intelligence* and *promotion*, and *appraisal* phases of the decision process.

The 1988 Constitution required a new form of water resources governance. In phase of implementation, the 'new' prescription – the federal 1997 Water Policy – had invoked a requirement that the management of the water resources shall include a committee of stakeholders. This committee, the *São Francisco* River Basin Committee – CBHSF, is in charge of leading that river system towards sustainability, overseeing and implementing the water policy's instruments for the watershed. In this section, I describe the major federal and regional frameworks and institutions that have been governing this system, which includes besides the committee, other institutions members of the 'new'

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[2] This research uses the term jurisdiction incorporating geographical-physical or administrative aspects.

[3] According to Clark (2002), the *decision process* constitutes of seven functions. During the *Intelligence* (or planning) information is gathered. Policy alternatives are advocated in the *Promotion* phase and, created and enacted during *Prescription*. The *Invocation* phase means implementation. Issues are resolved during *Application*. In the *Appraisal*, both prescription and decision process are assessed. A policy life cycle comes to an end in the *Termination* phase.

National System of Water Resources Management. This chapter explains what Figure 4.1 illustrates, the major changes in water use rights and ownership concerning the SFR during the last and present centuries.

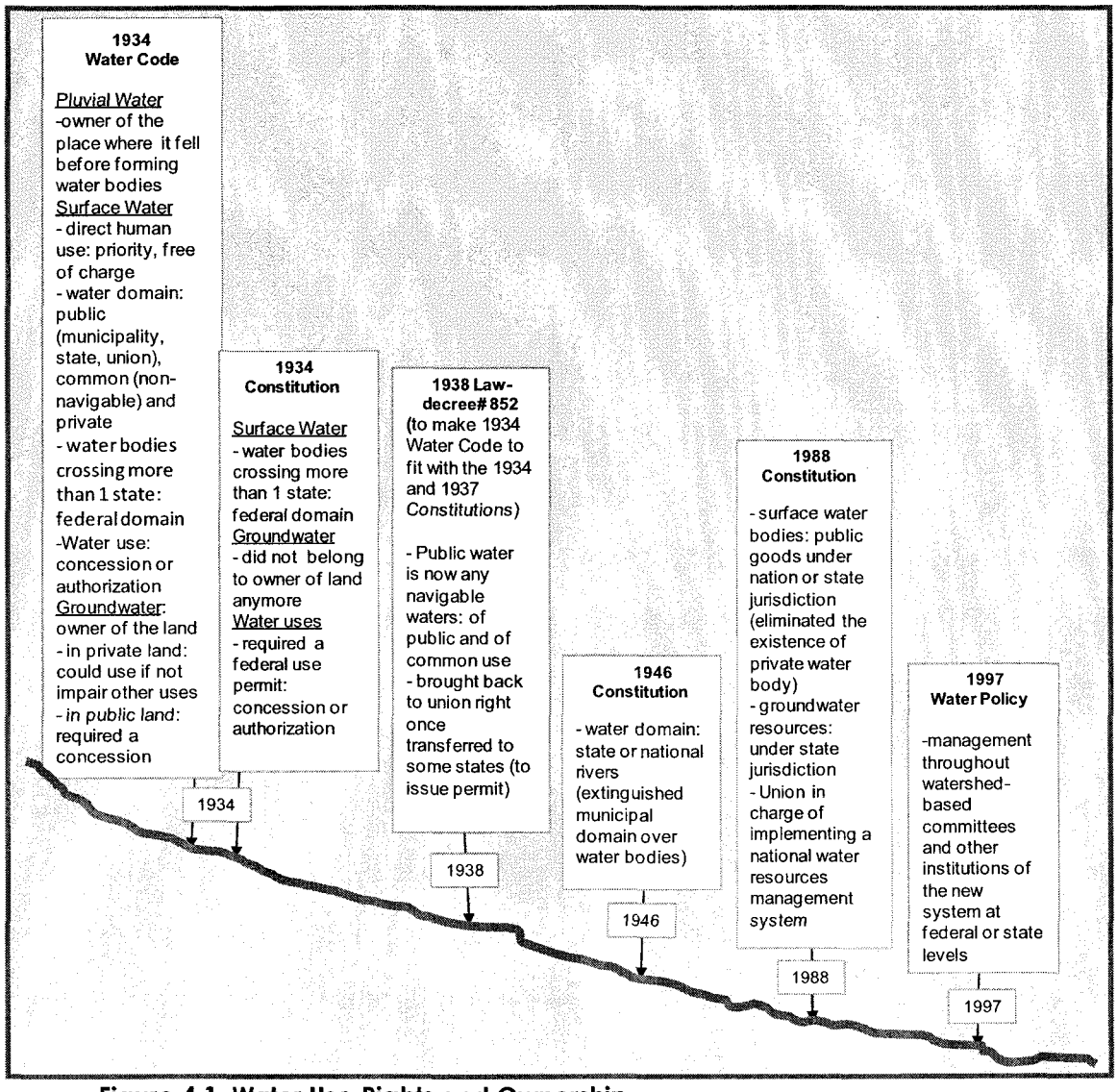

Figure 4.1. Water Use Rights and Ownership

Legal and Institutional Frameworks: Past and Present

In the beginning of the twentieth century, water management in Brazil was chaotic. It lacked planning. It did not provide control and protection over water bodies. The 1891 Constitution [Art. 72, §17] had assured that, in the absence of becoming a

public good, resources of the land, such as groundwater, belonged to the property's owner. Administrative agencies' sanctions or veto governed user's rights of surface water. The grant was usually provided after the construction of the water project, too late to make any adjustment (Pompeu 2006). Regarding navigation, the 1891 Constitution stated that federal law would regulate Union and state's right of legislating on the issue of interior navigation [Art. 13], and that Congress was in charge of creating law to regulate navigation in rivers washing more than one state [Art. 34, 6°].

Starting in the 1930s, under a nationalist government, a new legal framework, the 1934 Water Code introduced means for the administration of water as a precious natural resource.[4] But the code focused upon industrial and hydropower uses to aid the development of the nation. Surface water withdrawal of federal resources such as the *Velho Chico* required a government concession or authorization. In a concession, the provision of the service was delegated to others. It took place for the purpose of public good. In the case of authorization, the right of use was provided for private benefit [1934 Water Code, Art.43]. In some cases, the entity issuing the certificate, the Agriculture Ministry exempted the user of the need of having it. Groundwater did not belong to the owner of the land anymore according to the 1934 Constitution [Art. 118]. But the proprietor could use the resource under certain conditions and with permits: not changing its natural course and without impair public and existing uses [1934 Water Code, Art.96; 1934 Constitution, Art.119].

The 1940s and early 1950s images and studies of the basin's towns and cities demonstrate the population's precarious access to freshwater (Gautherot and Frota 1995; Azevedo 1946; Baity 1951; Pierson 1972, vol. 1). This issue is relevant for this research because deals with the initially unstated objective, environmental justice. In all too many

[4] "Simply defined, nationalism is a deep love for one's own country coupled with a disregard if not dislike for other countries... A somewhat more sophisticated definition of nationalism is that of a group consciousness that attributes great value to the nation-state, to which unswerving devotion is tendered" (Burns 1968, 3).

instances, besides shallow wells, small rain retention reservoirs, and seasonal water bodies, water supply consisted of the work of *aguadeiros* or *botadeira de água*, men or women who collected small volumes of water from the SFR and other water bodies and sold them to households. Some cities had water delivered only to public fountains, *chafarizes*, from which water carriers also obtained water (Pierson 1972, vol. 1, vol. 2; Gautherot and Frota 1995). In *Bom Jesus da Lapa*, an interesting labor division regarding water supply took place. Most of women and children carried water in clay containers, large cans and inside of a pumpkin-like fruit, *cabaça (Cucurbita lagenaria)*, on their head or in their hands. Men often used donkeys to carry barrels of water (Gautherot and Frota 1995). This human delivery system was a necessary part of women's household obligations and a paid occupation for many men. Locals also carried vessels in Ox-carts.

Nonetheless, already in the 1950s, things started to change due to implementation of autonomous agencies (Silva 1998). The law which approved the General Plan for the basin also called for cooperation among the Development Commission for the Valley – CVSF and the government of municipalities of the basin to improve public water supply systems [Law# 2,599 of 1955; Decree# 38, 969 of 1956]. CVSF funded the drilling of wells for water supply of rural populations (Serebrenick 1961). The federal health agency, *Serviço de Saúde Pública* – SESP, which resulted from the support of the Rockefeller Foundation helped CVSF and several municipalities to build or improve their water treatment stations. The endeavor led to the creation of independent public water providers systems, the *Serviço Autônomo de Água e Esgoto* – SAAE. *Pirapora*, *Bom Jesus da Lapa*, *Juazeiro* and *Penedo* benefited from that undertaking (Serebrenick 1961, Pierson 1972, vol. 1) (Figure 4.2 below). The Chico's water and SAAE systems still provide drinking water for those municipalities. State and municipal arrangements have existed in other places. In 2006, for example, Pernambucan state agency was in charge of the management of the service in *Petrolina* and used SFR's water. In 2007, *Sergipe* state

water agency oversaw public well systems in *Santana do São Francisco* and *Brejo Grande*.

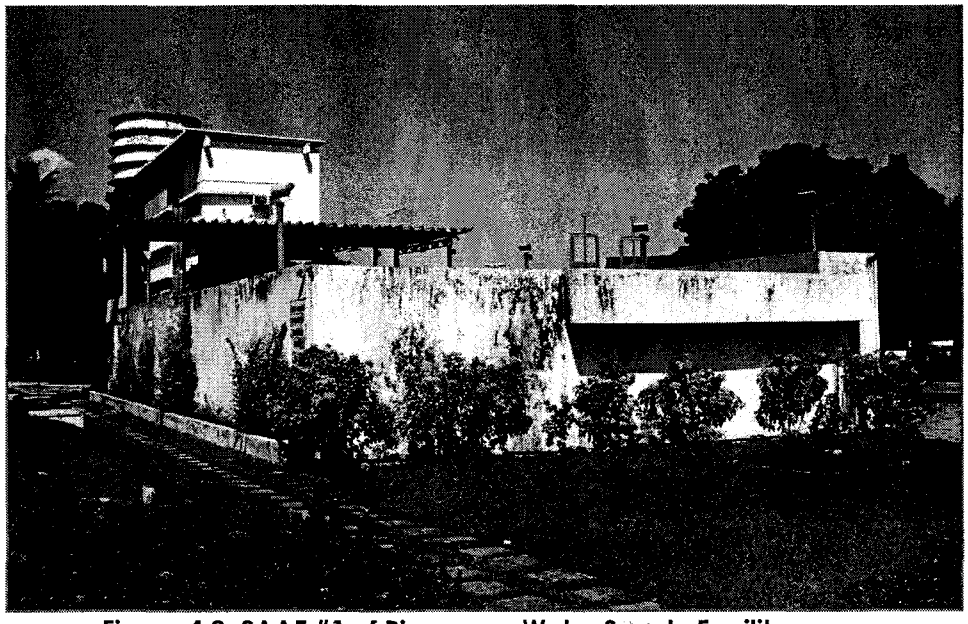

Figure 4.2. SAAE #1 of Pirapora – Water Supply Facility
Source: Luci Nascimento May 2007

The access to public water supply in the basin has improved. In the early 1980s, 81% of urban populations in the valley benefited from it (MME 1983a). The number in recent years is of 95% (CBHSF 2004). But, human need has not always been met. According to the CBHSF's management plan (2004), human demand represented a small, but not an unimportant number (16%), in relation to the major uses of the basin's water: the non-consumptive one, hydropower generation, and a consumptive one, irrigation, which alone accounted for 69% of the water withdrawal in the basin.[5] The *Velho Chico* is also the sink for waste. The organic load of domestic sewage of the basin

[5] Some 9% is withdrawal for industrial use, 4% for animal and 2% for rural supply (CBHSF 2004).

is of 499 tons of BOD5 per day. The Upper-SFR accounts for 62% of the organic load demand of the water body (CBHSF 2004).[6]

The plan established an ecological discharge, an average daily river flow discharge of 1,300 m^3/s at the river's mouth to allow the maintenance of aquatic life and ecosystem functions (CBHSF 2004).

The section below chronologically describes characteristics of the legal frameworks in their relevance to the water use of the *São Francisco* River. The Table 4.1 below summarizes the three major policies that were completely or partially in effect in 2008. The table's contents are taken from the policies listed.

[6] *Five-day biological oxygen demand (BOD5) means the necessary amount of dissolved oxygen* consumed in five days by biological processes to break down organic matter discharged into a water body.

Table 4.1. The Main Legal Federal Frameworks that Today Govern the SFR

Legal Instruments	Rationality (Driven by, Base Values)	Objective(s) Mandate(s)	Policy Instrument(s)	Who Manages	Form of Management	Public Participation	Status Decision Function (s)
The 1934 Water Code	-Nationalism (e.g., authorizations and concession for water use provided only to Brazilians or companies organized in Brazil -Developmen-tism (e.g., industrial development, hydropower generation)	-Rational use of water resources -Industrial development -Hydropower generation -Human supply is priority -Navigation shall not be impaired -Introduced the idea of "Polluter Pays Principle" -Introduced the idea of "User Pays Principle" for water resources -Mandated the creation of a hydropower and electric energy federal council: to assess hydropower permit's requests	-Required user's rights permits (idea of *outorga*): concession for public good purpose, authorization for private benefit, and exemption of permit for specific cases - Made water pollution a crime when not authorized and paid for	-SFR's water under federal control. It crosses states' borders and the nation uses the waterfalls for power generation and navigation - Agriculture Ministry in charge of implementation -Rain belongs to the owner of the land where it falls, when it becomes water bodies other rules apply. -Owner of the land can use groundwater if that do not impair public use (the 1934 Constitution altered that)	-Centralized: *São Francisco* River under federal control	-No mention -Public not involved	-Most regulations deal with hydropower issues -It ended up focusing on a single use (hydropower) -Partially still in *application* phase

Table 4.1. – *Continued.*

Legal Instrument	Rationality (Driven by, Base Values)	Objective(s) Mandate(s)	Policy Instrument(s)	Who Manages	Form of Management	Public Participation	Status Decision Function (s)
The 1988 Federal Constitution	-Democracy: Democratic state after twenty-one years of military dictatorship -Decentralization (e.g., different sphere of government, councils) -Representative	-Compensation for water used for hydropower generation -Only Union can legislate on water/ energy, -National system of water resources management and establish criteria for water use grants' system -Environmental Protection - The national health system must monitor water for human consumption -The use of water resources in indigenous peoples' land *requires* Congressional approval -"Polluter Pays Principle"	-Incontestable power -Any citizen can prosecute the state to eliminate the act which causes environmental harm -Environmental Impact Assessment is required before any work that might threat the environment -Authorization, concession, and permit: hydropower	-Union (SFR and federal tributaries), states (state's tributaries, groundwater)	-Decentralized among Union, States, Federal District	- Public participation: vote, plebiscites, referenda, popular initiatives, and councils	-*Invocation* and *Application*

Table 4.1. – *Continued.*

Legal Instrument	Rationality (Driven by, Base Values)	Objective(s) Mandate(s)	Policy Instrument(s)	Who Manages	Form of Management	Public Participation	Status Decision Function (s)
The 1997 Water Policy	-Dublin Statement -The French *model* -*São Paulo* Water Policy -Water as a public good -Water as a limited resource, with economic value -Primary use under scarcity situations: human and other animal species -Water management based upon multiple uses -Watershed-based management -Decentralized and *participatory* management	-Creates the water resources national *management* system - Water availability and quality to present and future generations -Rational and integrated use of water resources seeking sustainable development -Seeks to prevent and to protect against natural and anthropogenic critical water events -"User Pays *Principle*"	-Management plan -Water bodies *classification* according to its major uses -Permit system for water use (*outorga*) – except to insignificant applications -Payment for water use -Water resources Information system -User database	- Water Resources Councils -River Basin Committees -Water Agencies -Union, Federal District, and States Agencies	-Decentralized and participatory	-Mandatory participation of government, *users groups* and civil society members	*-Invocation and Application*

The 1934 Water Code (WC)[7]

On July 10, 1934, a Federal Decree [# 24,643] proclaimed the Water Code to regulate usage of the nation's water. It aimed at rational management of Brazil's waters, especially for navigation, industrial applications and hydropower generation. The policy set direct free-of-charge human use as a priority to supply the needs of the population [1934 WC, Art. 34, Art. 36 §1°, Art. 71 §3°]. Usage could not impair navigation except in the case of priority uses such as drinking water and special national's interests [1934 WC, Art. 37, Art. 48 a, b]. The policy characterized waters as public, common (non-navigable) and private [1934 WC, Art. 1, Art. 7, Art. 8]. It made clear that public water ownership was to be under one of the three levels of government: municipality, state or Union [1934 WC, art. 29]. The Agriculture Ministry was in charge of carrying out the implementation of this policy.

Rain, before forming water bodies and becoming subjected to regulation, belonged to property owners [1934 WC Art. 103, Art. 104]. This still holds today. The 1934 Water Code assured that the land owner could use groundwater if it did not impair other uses, including public ones [1934 WC, Art. 96]. The use of groundwater on public land required a grant (concession) [1934 WC, Art. 101]. One week after the approval of the 1934 Water Code, the 1934 Brazilian Constitution specified that subsurface resources no longer belonged to the land owner and required federal permission for exploitation and industrial uses even in the case of private lands. The grant was in the form of authorization or concession [1934 Brazilian Constitution, Art. 118 and Art. 119].

Regarding surface water, as a general rule, the owner of land crossed by public, common and private water could use it under the condition that human supply was still

[7] The 1945 Mineral Water Code [Law-decree# 7,841 of 1945] regulates the use of mineral waters [The 1945 Mineral Water Code]. Mineral water results from natural or artificial sources and its physical-chemical properties differentiate it from common water. In Brazil, mineral water has therapeutic purposes (Vaitsman and Vaitsman 2005). The 1967 Mining Code (*Código de Minas*) [Law-decree# 227 of 1967] required concession and authorization for the use of underground resources, such as both mineral and groundwater [Art. 2, Art.4]. The 1988 Constitution placed groundwater under state and Federal District jurisdictions [1988 Constitution, Art.26].

the primary use [1934 WC, Art. 34, Art. 71, §3°]. The use of public waters could be free or charged for [Art. 36, §2°].[8] The article suggested the idea of "User Pays Principle". Users did not have to pay if the water was used to meet basic needs [Art. 34]. The use of public waters for agriculture, industry or hygiene required a concession permit when the service benefitted the public good; and authorization if the water resulted in private benefit. Insignificant uses received an exemption permit, but the user needed to apply for it [1934 WC, Art. 43, Pompeu 2006]. The 1997 Water Policy eliminated the permit for insignificant uses and for human supply for small rural populations [1997 BWP, Art.12, §1° I, II, III]. The 1934 Water Code mandated that concession and authorization's periods for water withdrawal had to be issued for a fixed period, that could not be longer than thirty years [1934 WC, Art. 43, §2°]. A concessioner that did not function for a consecutive three-year period would lose the grant [1934 WC, Art. 43, §3°].

The 1934 Water Code introduced the initiative of a permit system for using water, today named *outorga* (grant) [1934 WC, Art. 43]. The National Department for Water and Energy – DNAEE and predecessor entities used it at national level for hydropower infrastructure. Indeed, most of the legal instruments associated with the 1934 Water Code regulated energy issues (Granziera 2007a). The idea of applications rights in the 1934 Water Code was linked to water quantity and not quality (Granziera 2006). *São Paulo* was the first to apply the instrument at state level. Bahia issued its first grant in 1988, for an irrigation project (Bahia SRH-BA 2005).

The 1934 Water Code made references to water pollution. The policy prohibited construction capable of polluting groundwater [1934 WC, Art.98]. It also made illicit the activity of contaminating any water and harming others [1934 WC, Art.109]. Polluting water was a crime [Art. 109] and the violator was subject to criminal and administrative charges [1934 WC, Art. 110]. Another advance in the 1934 Water Code regarding water

[8] The 1916 Civil Code established that the use of public goods could be free or charged for [Art. 68]. But, the payment for water never took place based upon that law either (Granziera 2006).

resource management was that it included the "Polluter Pays Principle." It mandated that the one polluting would be charged for the restoration of the quality of the water body [1934 WC, Art. 110]. Nevertheless with permit, industry and agriculture could pollute water. The violator was supposed to purify it after use [1934 WC, Art. 111] and pay for the favor of being allowed to spoil it [1934 WC, Art. 112]. A holistic and ecological approach of waterways management did not exist. Indeed, the Article 111 of the 1934 Water Code opened the exception of permitted pollution. It established that if agriculture and industry users did not restore the polluted water, they should make sure that it would follow the natural sewage flow [1934 WC, Art. 111]. In the 1930s sewage was mostly discharged into water bodies in a raw form, constituting the ordinary way.

In public and common waters, fishing and hunting were subjected to federal as well as complementary and supplementary states laws [1934 Constitution, Art. 5, XIX, j; 1934 Constitution, Art. 5, §3°; 1934 WC, Art. 42]. The code and constitution did not specify the laws.

The 1934 Water Code had a nationalistic tone. It mandated that authorizations and concession for water use shall be given only to Brazilians or companies organized in Brazil [1934 WC, Art.195, §1°]. The nation focused on and provided incentives to sectors which would lead the country towards national development. Hydropower had all the incentives to become the major use of Brazilian rivers, as the future showed. The 1934 Water Code [Art. 139] regulated the use of waters for hydropower generation in both public and private domains [Art. 139]. Authorizations or concessions system regulated hydropower development [Art. 139]. The *Serviço de Águas* of the Agriculture Ministry was in-charge of assessing and recommending in favor or against granting a permit to a project [Art. 144, b]. But, the Union could empower states to provide authorization and concession for hydropower generation in the state's territory and water bodies [Art. 63, Art.191]. Management used political, not watershed boundaries. In general terms, the

grant system at the national level was employed in the following way: the Agriculture Minister recommended and the president then gave the concession to use waterfalls for hydropower generation for a normal period of thirty years [Art. 150, Art. 157]. As a federal resource, the president conceded the use of the SFR water's hydropower potential initially to CHESF for fifty years [Decree# 19,706 of 1945]. Regarding private uses of water resources for energy, the Agriculture Minister issued the authorizations for hydropower use for a maximum period of 30 years, renewable for that same period of time or less than that [Art.170, Art. 171, Art.172]. The grant system was contradictory. Uses for the public good (concessions) required the approval of the nation's president. But, the Agriculture Minister could authorize exploitation of hydropower for private benefit.

Hydropower development had to meet various conditions specified by law: riparian communities would have their basic needs met, navigation and irrigation would be able to happen, floods would be controlled and fish would be able to circulate and would be protected [1934 WC, Art. 143]. In the case of the *São Francisco*, those conditions were not met for some uses or for some residents. In 2008, for example, dams were obstacles for fish migration. The river was not managed for navigation. In addition, people living in the basin, even close to the water body had no access to public water supply. The use of the waters of the *Velho Chico* needed to meet the priority of hydropower generation for national development imposed by the elites in governmental positions. Locals had no power (e.g., wealth and political) to demand a different reality.

The 1934 Water Code did not guarantee the right to use natural water bodies. The federal policy's text specified that any water body in public or private land would serve the main purpose of achieving basic needs. But, in the SFR basin as in many other parts of the Northeast of Brazil, landowners built visible and invisible barriers to keep locals away from water.

In 1938, Law-decree# 852 amended the 1934 Water Code to fit with the 1934 Constitution. It assured that water bodies in more than one state were under the Union's jurisdiction, and that navigable waters were public and of common uses [Art. 2, Art. 3]. The amendment increased federal control over water resources, bringing back to the Union control once transferred to states, such as *São Paulo* and *Minas Gerais* [Art. 4]. The law-decree emphasized hydropower generation issues assuring national domain of waterfalls and other hydropower sources.

According to Pompeu (2006), the 1934 Water Code was an advanced piece of legislation for its time. It is true. It included the ideas of "Polluter Pays Principle," "User Pays Principle," and water use right (later known as *outorga*) or permits system. But, the insufficient implementation and complementary regulations led to its failures (Pompeu 2006). Sections of the 1934 Water Code are still into force. But, the 1988 Constitution altered it to, among other things, place water bodies only under public jurisdictions belonging to the Union or the states [1988 Constitution, Art. 20, III; 1988 Constitution, Art. 26, I]. The 1997 Water Policy also modified the 1930s policy (Pompeu 2006).

Brazilian Constitutions (BRC)

This section examined Brazilian Federal Constitutions (BRC) of the twentieth and present centuries to identify the mandated requirements regarding water resources management. The 1988 Constitution is the current law, the one which prevails. But I described previous ones to show how the legal rights have evolved.

This section also examined issues concerning floods and droughts since the use of water in the basin has been related to anti-drought and flood policies and development programs as well. The nation, throughout its constitutions, has on different situations, provided legal and financial support for the valley and the Northeast of Brazil. But

regarding environmental protection, the 1988 Constitution has substantially increased the requirements far beyond earlier documents.

The 1934 Constitution [1934 BRC, Art. 5, XV; 1934 BRC, Art. 177] mandated that, the Union should permanently protect the states of the North against the effects of droughts. The Union had to spend at least 4% of the total national tributary income [1934 BRC, Art. 177], distributed as follows: three-fourths for the implementation of a plan and one-fourths for emergency support [1934 BRC, Art. 177, §1°]. (Please see p. 27 for a description of the drought phenomenon).

Water bodies crossing more than one state were under the nation's jurisdiction [1934 BRC, Art. 20, II]. This holds until today. The 1934 Constitution asserted that mineral resources and waterfalls were not part of the land and did not belong to its owners [1934 BRC, Art. 118]. The use of water and hydropower required federal government concession and authorization and would be given only to Brazilians or Brazilian companies [1934 BRC, Art. 119, §1°]. Only the Union could legislate about water, ports, inland navigation, and fishing [1934 BRC, art. 5, XIX, e, j]. Under the 1988 Constitution this provision holds. Only the Union can legislate about water uses rights (Art.22, IV).

The 1937 Constitution did not include the support for the drought prone area and Northern states. It was promulgated under special conditions, civilian rule. The federal state was still in the forefront of water resources management. The 1937 Constitution assured that a watercourse crossing more than one state was still under the Union's jurisdiction [1937 BRC, Art. 36, b]. According to Pompeu (2006), Law-decree# 852 of 1938 also altered the 1934 Water Code to fit to the 1937 Constitution, characterizing also as public waters any navigable water body. Mineral resources, water, and waterfalls were still treated as separable elements of the land's ownership [1937 BRC, Art. 143] and required "use rights" authorization provided only to Brazilians or Brazilian companies [1937

BRC, Art. 143 §1°]. The Union was still in charge of legislating over waters, inland navigation, hydropower and fishing [1937 BRC, Art.16 XI, XII, and XIV].

The 1946 Constitution mandated the economic development of the basin. Article 29 under the constitutionally-ordained temporary measures' section established that not less than 1% of the national treasury income should be used to create and implement an economic development plan for the SF River basin for a twenty-year period [1946 BRC, Art. 29 – ADCT]. An important valley development commission, CVSF, was created to address that task. It was the first attempt to implement a unified management for the basin. Despite the use of the valley to delineate the area of management, it was not a form of ecosystem-based management. Environmental protection and restoration were not the priority. The focus embodied a more economic approach seeking the use of the resources of the valley for its development (CVSF 1951, 1959).

Article 5 of the 1946 Constitution mandated the Union's fight against the effects of droughts and floods, and rural endemic diseases [1946 BRC, Art. 5, XIII]. Article 198 assured the financial support. It guaranteed that at least 3% of the total of the national tributary income should be used against the social and economic effects of droughts in the Northeast, some one-third of the 3% to be applied for emergency actions [1946 BRC, Art 198, §1°].

Mineral resources and waterfalls once again did not belong to the owner of the land [1946 BRC, Art. 152], as still is the case today. Their use required authorization or concession provided to Brazilians or Brazilians companies [1946 BRC, Art. 153, §1°]. The 1946 Constitution yet assured that watercourses crossing more than one state were under national domain [1946 BRC, Art. 34, I] and that only the Union could legislate regarding underground resources, water, energy, fishing, ports and navigation [Art. 5, XV, i, I]. Lakes and rivers located only in one state belonged to it [1946 BRC, Art. 35]. The 1946 Constitution extinguished the existence of rivers under municipal jurisdiction [Pompeu

2006]. Indeed, it only specified national and state's water bodies [1946 BRC, Art. 34, I; Art. 35]. The Constitution altered the 1934 Water Code that used to include municipal water bodies. The 1934 BRC [Art. 21] and the 1937 BRC [Art. 37] had placed under states' jurisdiction only water bodies assured by existing legislation minus what the respective constitutions defined as the Union's water.

The 1967 Constitution like the 1937 one was promulgated during ruling, not civilian (1937-1945) but military (1964-1985) regime. The 1967 BRC mandated Union's fight against public calamities, such as droughts and floods. But it did not specify areas for support [1967 BRC, art. 8, XII]. The 1967 Constitution required that the Union established and implemented regional development plans. But, it did not identify the SFR basin as a priority area [1967 BRC, Art. 8, XIII]. In the case of the *Velho Chico* Valley, this constitution was a step backwards. In addition to the lack of special attention and financial support for the development of the valley such as the one provided by the 1946 Constitution, it did not reinstate the presidential commission created in 1948 to oversee the river basin's development – CVSF. The superintendence that replaced it, SUVALE, was not linked directly to the Brazilian Presidency. It was still a development agency for the valley, but under the political jurisdiction of the Interior Ministry, that incorporated and provided funds for the new entity.

The Union was still in-charge of creating legislation on fishing, water, energy, port and navigation (1967 BRC, Art. 8, XVII, h, i, m). According to the 1967 Constitution, water bodies crossing state boundaries were still under the Union's jurisdiction (1967 BRC, Art. 4, II). Lakes and rivers located only in one state belong to it (1967 BRC, Art. 5). The 1967 Constitution did not change the fact that mineral resources and resources that can generate hydropower do not belong to the soil (1967 BRC, Art. 161) or that their exploitation required authorization or concession to be given to Brazilian or companies organized in Brazil (1967 BRC, Art. 161, §1°).

The 1988 Constitution, the present one, authorized the use of federal resources for the development of the northeast of Brazil, especially the semi-arid region, in which the majority of the basin is located. Nevertheless, it does not specify the valley as a priority area. It mandates that, 3% of the revenue from income and profits taxes and industrialized product taxes will be invested in programs for the North, Northeast, and Center-West regions accordingly to their regional development plans. The semi-arid part of Brazil is supposed to get half of the income that the Northeast is entitled to receive [2007 Constitutional Addendum#55, 1988 BRC, Art. 159, I, c].

In addition to the above mentioned, the Union is supposed to invest resources in irrigation for a period of twenty-five years, with at least 50% of this to be applied in the Northeast Region, preferentially in the semi-arid [2004 Constitutional Addendum#43, 1998 BRC- ADCT, Art 42, II]. The 1988 Constitution maintained the article about fighting against the effects of droughts and floods [1988 BRC, Art. 21, XVIII]. Indeed, it is a priority of the nation to use economically and socially water resources in low income and in drought prone areas [1988 BRC, Art. 43, § 2 °, IV]. Thus indirectly it favors economic development.

Regarding water resources management, this constitution introduced changes altering the 1934 Water Code. It declared that all surface water bodies are public goods under the nation or states jurisdictions [1988 BRC, Art.20, III; 1988 BRC, Art. 22, IV; 1988 BRC, Art. 26, I]. It eliminated the existence of private water bodies. Groundwater resources were placed under the responsibility of states [1988 BRC, Art. 26, I]. The state agencies were in charge of issuing permits for groundwater withdrawal.

The 1988 Constitution maintained that, lakes, rivers, and any flowing waterway on federal lands, or that cross more than one state, such as the *São Francisco River*, or that serve as boundaries or are shared among other countries belong to the Union, which has jurisdiction over them [1988 BRC, Art. 20, III]. Also according to the 1988 Brazilian Constitution, the water bodies that were not categorized above, and which do not result

from work carried out by the Union belong to the state where it is located [1988 BRC, Art. 26, I].

Another change was that, the 1988 document now asserts that the Union is in charge of implementing a national system for the management of water resources and for the definition of criteria for the authorization of water resources uses [1988 BRC, Art. 21, XIX]. The 1997 Water Policy regulated the 1988 Constitution, introducing the elements of the new system. The 1988 Constitution maintained that only the Union could legislate on the matter of water in general terms for all the units of the federation and under national control [1988 BRC, Art.22, IV]. All spheres of government can administratively manage the resources under their jurisdiction regarding preservation, use and restoration. But, they cannot award ownership rights over waters (Granziera 2006). Municipalities do not have jurisdiction over water resources, but via a permit or concession can be in charge of providing public services [1988 BRC, Art. 30, V]. The provision of water supply, sewage treatment and solid waste management are good examples of covered services. As in the case of water, only the Union can legislate in matters of energy, port and navigation [1998 BRC, Art.22, IV, X]. The Union, states and municipalities can legislate concurrently on fishing and environmental protection [1998 BRC, Art. 24, VI].

The 1988 Constitution established other issues regarding water quality, quantity and use. The 1988 Constitution also specified that the health system has to supervise and control drinking water quality [1988 BRC, Art. 200, VI]. The Union is in-charge of creating directives for basic sanitation [1988 BRC, Art. 21, XX]. It provides general guidance, but, the Union, states, the Federal District, and municipalities are all accountable for improving water and sewage systems [1988 BRC, Art.21, XX; 1988 BRC, Art. 23, IX].

The 1988 BRC maintained that hydropower potential does not belong to the land. It belongs to the Union [1988 BRC, Art.176]. The 1988 Constitution authorized the Union to

carry out or provide authorization, concession or permission to the exploitation of hydropower resources and hydro-potentials in coordination with states, and navigation transport and ports [1988 BRC, Art. 21, XII, b, d, f; 1988 BRC Art. 176]. Municipalities, states, Federal District and federal administrative agencies were entitled to receive parts of the income generated by the exploitation of water resources for electric power [1988 BRC, Art. 20, §1°]. They should also oversee water resource use under their jurisdictions (1988 BRC, Art. 23, XI). The Law# 7,990 of Dec 28, 1989, institutionalized the financial compensation. The distribution of benefits was based upon the energy produced and the area flooded by a dam's reservoir. The division of reparation attracts political support for the existence of hydropower complexes. In addition, the constitution established that, on indigenous land, the water resources' exploitation would depend upon National Congress approval, after hearing local stakeholders [1988 BRC, Art. 231, §3°]. The indigenous communities involved are entitled to receive the benefits of such exploitation [1988 BRC, Art 231, §3°].[9]

Regarding ecological security, the 1988 Constitution mandated a safe environment for everyone. It established that environmental protection is one of the general principles which shall be regarded while developing any economic activity [1988 BRC, Art. 170, VI]. Everyone has the right to an "ecologically balanced environment," which should be safeguarded by government and community [1988 BRC, Chapter VI, Environment, Art. 225]. In order to meet such a goal, the constitution provides some requirements, such as the control of production, sale and use of actions and substances that can harm the environment [1988 BRC, Art. 225, V]. The 1988 Constitution also required an environmental impact study for activities that can harm the environment. The results of such assessments shall be made public [1988 BRC, Art. 225,

[9] In the case of the SFRB, indigenous groups have received financial compensation for other reasons. For example, the members of nation *Tuxá*, displaced by Itaparica Dam's reservoir, survive from a temporary payment CHESF pays due to the inability of production in the land of resettlement (Tomáz *et al.* n.d.b.).

IV]. This constitution included the "Polluter Pays Principle". The polluter is subjected to penal and administrative charges, besides providing for environmental restoration [1988 BRC, Art. 225, §3°].[10]

The government at all levels (Union, states, federal district and municipalities) shall protect the environment and fight pollution [1988 BRC, Art. 23, VI] and legislate concurrently on it [1988 BRC, Art. 24, VI]. If all that fails and in any circumstances, the 1988 Constitution assured that any person can file individual legal action to nullify an act in which the state participates and causes harm to the environment [1988 BRC, Art. 5, LXXIII].[11] But in Brazil, a big difference exists between what is written in the law and what is implemented and enforced. It is a clear example of implementation failure. A little more than twenty years after the approval of the 1988 Constitution environmental problems are still present in the basin and nation.

After twenty one years of military dictatorship, the guarantee of public participation is another novel contribution of the 1988 Constitution. Individuals can choose by voting in elections, plebiscites, referenda, popular initiatives [1988 BRC, Art. 14]. They can also engage in public management through councils in the three spheres of government with well defined jurisdictional boundaries and in different sectors of the society [e.g., Art. 198, I and III – health; and Art. 204, II – social services].

Councils include representatives from governmental agencies and civil society. But, the real and effective significance of civil society's participation in such councils are

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[10] The1981 National Environmental Policy is an ally for environmental protection. The 1981 policy mandates the safeguard of the national environment, including the waters [Law# 6,938 of 1981, Art.2, Art.3, V]. The National Environmental Institute is in charge of implementing this policy. The 6,938 requires an environmental permit for all activities that will cause significant environmental impact under public or private jurisdiction [1981 National Environmental Policy, Art. 10; IBAMA 2000]. The environmental licensing process requires an environmental impact assessment. It also demands public participation.

[11] In the judicial system, other legal instruments can be used for the protection of the environment: Law# 4,717 of1965 – Law of Public Action [Law of Public Action# 4,717 of 1965, Art. 1] seeks to eliminate a cause of damage; and Law# 7,347 of 1985 – Law of Public Civil Action [Law of Public Civil Action # 7,347 of 1985, Art. 1, I] assures protection even if the damage has not occurred yet. The social movement used the civil action instrument attempting to stop the construction of the inter-basin water transference project, the *Transposição*. But, in the end, the Supreme Court did not decide in favor of stopping the project.

indeed questionable for several reasons. Representatives of popular classes are rarely part of the councils. Civil society representatives have weak ties with the group they represent. Governmental representatives usually control the councils' agenda. In addition, at the municipal level, government often does not share power with councils (Abers and Keck 2008). In 2002, about 45% of the municipalities of the SFR valley had an environmental council: 80 acting as consulting and 146 as decision-making bodies (IBGE 2005).

The 1997 Brazilian Water Policy (1997 BWP)

The Federal Law # 9,433 of 1997, the Water Resources National Policy or Water Policy did both describe the law and introduce the new structure of water resources management in Brazil: a holistic approach with decentralized decision-making concerning participants and processes. The new system of governance did not reside only at the national level. States were following federal efforts and adapting to the new regime of watershed-based management. This novel system mandated new institutions, but it still included existing entities, such as the state agencies that dealt with water resources governance, in effect building-in the problems of the past.

The Water Policy seeks to assure water availability in adequate quality for present and future generations for multiple purposes. It seeks rational and integrated use of water resources, including for transportation, while pursuing sustainable development. It seeks to prevent and to protect against natural and anthropogenic events caused by inadequate use of water resources [1997 BWP, Art. 2].

The 1997 BWP contains six foundations [1997 BWP, Art. 1]. Water is a public resource, limited and with economic value, whose priority under scarcity conditions shall be given for direct human and animal supply. In comparison with the 1934 Water Code on the subject of human supply, the 1997 BWP is a step backwards. The new policy sets

this use as the first in the rank, but only under shortage conditions. It can certainly influence future uses choices, and create and increase the level of the population's vulnerability to water scarcity. The old framework did not establish circumstances, water for public supply was always a priority. It was a failure as regards implementation, but it is in the book. Still, according to the 1997 BWP, water shall be used for multiple objectives decided in a decentralized and participatory manner employing the watershed as unit of management. But, it did not change the fact that, political jurisdictions must address watershed issues. The decentralized participation includes representatives from Union, states and municipalities governmental bodies; water resources users; and civil society organizations [1997 BWP, Art. 33, Art. 34, Art. 39 and Art. 47].

The Water Resources National Policy contains six instruments [1997 BWP, Art. 5]. Plans guide watershed resources management. Water bodies are classified according to priority use and a water use right system regulates water use (*outorga*).[12] Payment for the use of water resources will exist. The use of a national information system is mandated to collect, store, organize and manage data to enable information-based decisions.[13] Brazilian President Fernando Henrique vetoed the description of the last item, the "compensation of municipalities" for the use of their lands by water reservoirs. But, the 1988 Constitution already assured recompense.

This policy introduced in practice the "User Pays Principle" for water resources management in Brazil [1997 BWP, Art. 5, IV]. Until now, Brazilians had paid for water treatment and distribution service, infrastructure and other activities that allow the supply

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[12] The National Environmental Council– CONAMA issued a new regulation [# 357] in March 17, 2005 for the purpose of water classification based upon its important uses, and condition and pattern of effluent discharge by substance. CONAMA Resolution# 357 establishes that discharge into water bodies shall only take place after effluent treatment and that, environmental agencies shall establish the maximum pollutant load for each facility/source [CONAMA# 357 of 2005, Art. 24, Art. 26]. The Health Ministry set quality requirements providers need to meet regarding water supply for human consumption [Health Ministry Administrative Rule# 518 of 2004].

[13] The National Water Agency, ANA, is in charge of the Water Resources National Information System – SNIRH. The entity that receives the warrant for the use of the water is the one in charge of monitoring its use and providing reports (*Water Resources Annual Use Declaration – Daurh*) to ANA if specified in the *outorga* document [Resolution ANA# 425 of 2004, Resolution ANA# 782 of 2009].

of the resource. Nevertheless, the law established that consumers will pay for the resource used, the water, a common good. The transference and withdrawal of surface and groundwater, the discharge of sewage or other forms of contaminants into water bodies, the use for hydropower generation and for any other use that alters water quality and quantity requires a permit, an *outorga* [1997 BWP, Art. 12].

Water use requests are susceptible to partial or full rejection, not all uses will be approved [1997 BWP, Art. 13]. Decisions are to be based upon the water bodies' classification and primary uses specified in the long-term watershed–based management plan [1997 BWP, Art. 13]. Grants might be subjected to suspensions [1997 BWP, Art. 15]. They can be revoked under different circumstances, as for example, if the user or use does not meet the guidelines specified, lack of use for three consecutive years, a need to prevent environmental degradation and in special circumstances as in the case of an unexpected climate event, and to allow the water body to meet primary uses during these situations [1997 BWP, Art. 15].

A water use right deadline is fixed and extends for a maximum of thirty-five years with the possibility of renewal [1997 BWP, Art. 16]. In the case of the *São Francisco* River, the agency in-charge, the National Water Agency – ANA has already issued water permits. As illustration, the water treatment facility of *Bom Jesus da Lapa* received the *outorga* to withdraw an average of 114.72 L/s of water from the *Velho Chico* for twenty-years [ANA Resolution# 239 of 2005].

ANA also issues "preventive *outorga*" to reserve water for uses whose projects are not yet implemented [Law# 9,984 of 2000, Art. 6], as in the case of the inter-basin water transfer project, *Transposição* and the sewage treatment station of *Penedo* [ANA Resolution# 29 of 2005 and ANA Resolution# 075 of 2002]. A number of activities do not require water use right and among them are the supply to small rural populations; insignificant transference, withdrawal, and accumulation of water; and the discharge of

unimportant amounts of pollutants into water bodies [1997 BWP, art.12, §1° I, II, III]. Nonetheless, all utilizations need to be included in a user database [1997 BWP, Art. 27, II].[14] The Union defined water use rights criteria in the 1997 Brazilian Water Policy [Art. 11 to Art.16, and Art. 18]. The Resolution# 16 of 2001 of the National Water Resources Council – CNRH details it adding information to the general criteria [CNRH Resolution# 16 of 2001].

The priority is to use the resources generated in a watershed within that basin [1997 BWP, Art. 22]. The revenue is intended to finance studies, programs and projects included in the watershed management plan [1997 BWP, Art. 22, I]. It should cover expenses of the administrative agencies' members of the National System of Water Resources Management in an amount not higher than 7.5% of the total received from water use [1997 BWP, Art. 22, §1°]. The Law# 10,881 of 2004 allows the profit from the use of the water resources to be used in the basin that generates it. In Brazil, only two federal rivers basins have implemented water payment system. The *São Francisco* River Basin is on its way. Regarding monitoring, the National Water Agency has setup the National Water Resources Information System, and the *São Francisco* is part of it.

The *São Francisco* River Basin Committee approved the plan for the watershed in 2004. Prior to the existence of the CBHSF, federal water bodies of the SFR had been classified according to their major uses. Following the requirements of the 1997 Water Policy and based upon the classification criteria of the National Environmental Council, the CBHSF published a temporary regulation to propose the freshwater-class-two for the *São Francisco* and the majority of its tributaries until each case could be analyzed [CBHSF Deliberation# 12 of 2004]. Class-two means that the surface body of freshwater will be able to support uses such as: drinking water supply, human contact (such as for

[14] For the *São Francisco* Case, insignificant amounts for withdraw is four liters per second (ANA 2008). If a basin has not a criteria suggested by the watershed committee and approved by the National Water Council, ANA establishes insignificant use as up to 1 L/s if the [ANA Resolution# 542 of 2004, Art. 4, III,ANA Resolution# 273 of 2009,Art.4, III].

swimming), support the aquatic life, and irrigation. The watershed plan maintained the class-two for most water bodies of the basin (CBHSF 2004).

The National Water Agency grants the right for the use of water for federal rivers, such as the *Velho Chico*. State agencies warrant the permit for state water bodies and groundwater and provide information on it to the National Water Agency. By December 2007, some 80% of the permits issued for the SFR basin granted the right of the application of the water for irrigation. Only 6.2% of the irrigation water came from groundwater (ANA 2009b).

The importance of the 1997 Water Policy is varied. It mandated public involvement. Decentralization and participation in the management was intended to include users of the resources and the water related civil society. Water resources administration would no longer be held only by executive governmental bodies. The 1997 Water Policy mandated the employment of permit systems, an idea that the 1934 water Code introduced. Besides the need for use right grants through *outorga*, the 1997 Water Policy also required payment for the use of water. It mandated the implementation of the "User Pays Principle." In the past, with exception of the hydropower providers, users received uses rights, but they did not have to pay for the water as the new policy now requires. In governmental irrigation projects, for example, users paid for the infrastructure and not for the water itself. Consumers will pay a "price" for the use of a public resource after the implementation of the system for the SFR watershed (Pompeu 2006).[15]

The # 9,433 policy altered the distribution of the income which results from water resources use for hydropower generation. The Water Resources Secretary of the Environmental Ministry will receive 4,04%, the National Water and Energy Department 3,06% and Science and Technology Ministry 2% of that financial resource. The aims are to

[15] It is not privatization of water. The user pays for the right of using it and do not have the ownership of the hydro resource. The nation, state and Federal District still hold the ownership of the natural resource.

allow the implementation of Water Policy, the National Water Resources Information System and to improve hydro-meteorological stations and studies [Art. 54]. Municipalities and states are also compensated for the use of the river to generate hydropower.

Inspiration for the National Model. From the international front, the French model of water resources management and the Dublin Statement have influenced the Brazilian 1997 Water Policy. One can find similarities among that policy and the French policies. For example, the French 1964 policy [Law # 62 of 1964] focused on water distribution and pollution prevention (Leal 1998). In France, watershed's borders also delimit water resources management and valley's committees were composed of civil society, users and government. *Outorga* was required for water withdrawal and discharge (Pompeu 2006, Moraru-de Loë 1993). The 1964 legislation included both principles "User Pays" and "Polluter Pays" (Leal 1998). The French 1992 policy [Law# 92-3 of 1992] emphasized holistic approaches of management. It included quantitative and qualitative aspects not only pollution elimination, but also protection and restoration of water quality and ecosystems. Management plans guide uses of the water for multiple uses of a watershed or groups of them (Leal 1998). Among other things, Brazil and the France adopted the watershed as unity of management, requiring watershed-based committees and agencies present in the government model, that were under a national council, in the case of France the inter-ministerial and in the Brazilian case, the water council. In both nations a watershed plan guided the management and included the "user pays principle".

The Dublin Statement on Water and Sustainable Development resulted from the International Conference on Water and the Environment (ICWE), in Dublin, Ireland. The conference included members of governmental, intergovernmental and non-governmental organizations and took place in January 1992. It ended with a set of principles and an agenda of actions to guide water resource management. The

gathering in Ireland was a preparatory meeting for the United Nations Conference on Environment and Development – UNCED or The Earth Summit or *Rio* 1992 which took place in Brazil in that same year. One of the outcomes of *Rio* 1992, the Agenda 21, in its chapter eighteen, called for integrated, sustainable, participatory, and watershed-based management of water resources. The influence of the Dublin Statement and consequently of *Agenda 21* was clear when compared to the Brazilian 1997 Water Policy's principles.

In the domestic sphere, the *São Paulo* Water Policy was an important step towards the model the nation has now [Law# 7,663 of 1991]. *São Paulo* state agencies' members participated in the discussion of the national water governance system (Abers and Keck 2006). The 1991 policy established the water management system for the state. It included a council and watershed committees both with representative from governmental entities, civil society and universities (Leal 1998). The system included a committee to coordinate the state management plan, and agencies to be the executive secretary for the committees (Leal 1998).

The Brazilian Water Resources Management System. Law #9,433 defined the policy and also created the framework of the Brazilian Water Resources Management System – SINGREH (Figure 4.3 below). The system was composed of the National Water Resources Council – CNRH and States and Federal district councils; the National Water Agency – ANA and watershed water agencies; watershed committees; and governmental entities dealing with water resources management, such as the Water Resources Secretary of the Environmental Ministry – SRHU. I have described the institutions at the federal level in Table 4.2 from legislations and multiple sources.

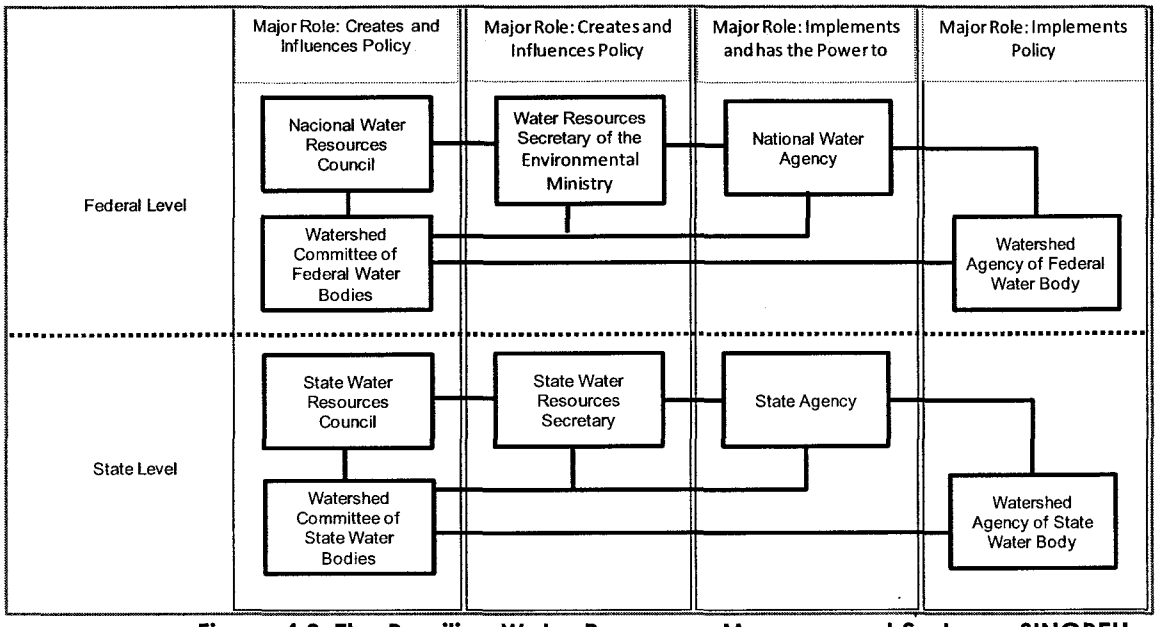

Figure 4.3. The Brazilian Water Resources Management System – SINGREH

Environmental entities at federal and state levels were also part of this system, because they regulated activities that might damage the environment. Additionally, the Health Ministry established water quality standards for water bodies used for direct and indirect consumption such as public water supply and swimming [CONAMA Resolution# 237 of 1997].

Table 4.2. The Brazilian Water Resources Management System and the SFR Basin

	Structure
Environmental Ministry (*Ministério do Meio Ambiente*) – MMA	-Dates back to 1930s -In 1973, it became an environmental secretary (*Secretaria Especial do Meio Ambiente*) – SEMA under the umbrella of Interior Ministry (*Department of Interior*) -Became an independent ministry only in 1992 [Law# 8,490 of 1992]
Water Resources National Council (*Conselho Nacional de Recursos Hídricos*) – CNRH	-Implemented in 1998 -Linked to the Environmental Ministry -The Environmental Ministry is its president -Members are representatives from: ministries and secretaries of the executive branch of the federal government with ties to water resources management; state water councils; water resources users' groups; and civil society's organizations -Decision-making: the number of representatives from the federal executive branch cannot be higher than half-plus-one of the total members of the council. Nonetheless, representatives of entities from various levels of government compose the majority of the CNRH -Importance: - At national level, decides upon the creation of agencies (and at state sphere, state water councils undertake the task) -In charge of deciding on the creation of national watershed committees and establishing criteria for the creation of committees' guiding rules -Commands and connects water resource's planning; national, regional and state planning; and users -Acts as a supreme court in the new framework of water resources management, such as deciding on matters arising among states' water councils and on projects which results go beyond the area of the state where they are implemented -Analyzes proposals for change in existing water resources legislations, and is a policy-making body regarding regulation for the implementation of the Water Policy -Approves and oversees the implementation of the national water resources management plan -Establishes general criteria for water use rights, the *outorga*, and for water charge/payment -Problem: -Because it is the highest sphere of decision-making, and governmental entities are majority, it repeats the traditional form of centralized decision. -*São Francisco* River: -The CNRH authorized the creation of the CBHSF -Decided in favor of the *São Francisco* River inter-basin scheme -The CNRH authorized the creation of the SFRB Watershed Agency

Table 4.2. – *Continued.*

	Structure
The Water Resources Secretary (*Secretaria de Recursos Hídricos*) – SRH-MMA, now SRHU The Water Resources and Urban Environment Secretary	- The SRH exists since 1995 - The Decree# 6,101 of 2007 transformed it in the Secretary of Water Resources and Urban Environment – SRHU -Linked to the MMA -Acts as the executive secretary for the National Water Resources Council -Importance: -Recommends and monitors water-related national environmental policies -Develops studies on water issues, provides training, and connects state councils -Provides administrative, technical and financial support for the National Council -Coordinates the restoration program for the *São Francisco* River Basin with the support of the National Integration Ministry
Water Resources State Councils	-State councils have similar tasks, but applied to state resources and basins.
Watershed Agency	-Linked to watershed committees -Funded by financial resources received from the payment for water use -Importance: -Implements policy -Committee's executive secretary -Keep database on water use and users of their valleys -Collect revenue from water use and decide upon projects that will employ the resources -Create the watershed management plan for committee's approval -Suggest water body employment's classes to basin committees -Suggest water prices to the basin committee -Undertake studies
Other entities of the Federal, State and Municipal Government	-The Environmental Institute – IBAMA: under the umbrella of the Environment Ministry, regulates activities that can damage the environment. As for example, IBAMA issue three types of environmental licenses: previous to the construction of the project, during implementation, and for operation (ANA 2005). -State environmental agencies: grant environmental permits -State water agencies: grant use right for water bodies under state's jurisdictions -Water and sewage supplier

Table 4.2. – *Continued.*

	Structure
National Water Agency (*Agência Nacional de Águas*) – ANA	- The Law # 9,984 of 2000 created the National Water Agency – ANA. It is linked to the Environmental Ministry -Funded by Union's budget funds and revenue from the use of federal water body -Importance: -implements the national water resources policies and oversees compliance of them -monitors the use of federal water bodies and grants use right (*outorga*). (In the case of hydropower only if the generation is equal or less than 1000 kW, otherwise the energy agency – ANEEL will issue the warrant) -The process of requiring *outorga* from ANA is free. ANA can issue two categories of *outorga*: previous to the construction to select resource (preventive), and for operation (ANA 2005). -Issues a statement on the sustainability of water resources regarding water related constructions – CERTOH, as in the case of the inter-basin water transfer project -Created and runs the Water Resources Information System – SNIRH. It collects and makes water related data available regarding uses, users, grants and water charge. The system monitors indicators of water quantity and quality. It is still in implementation, lacks historical data series for some indicators and locations. Before this new system, information was more on water quantity than quality -Undertakes and sub-contracts studies and provides support for river basin committees -ANA's actions shall be restricted by the watershed plan for each basin -*São Francisco* River: -ANA has undertaken and subcontracted studies about issues concerning the *Velho Chico* and its basin, and has provided support for the work of the SFRB committee, such as in the development of the watershed plan
River Basin Committee (*Comitê de Bacia*)	-Approved by water councils. In the case of federal rivers, the president of Brazil needs to approve it -President: peer-elected members select the president, vice-president, and secretary -Members: representatives of water resources users groups, governmental managers (e.g., federal and state agencies and municipalities), and the civil society. Representatives of the civil society shall hold at least 20% and users shall have 40% of the total of votes [CNRH Resolution # 24 of 2002, Art. 8, II and III]. Water related civil society entities include legally constituted: consortiums, associations, technical-educational-research institutions, non-governmental organizations. -Importance: -Promotes debates on water issues. -Resolution of use conflicts in water resources at lowest sphere. It is a decision-making and consulting entity -Approves watershed water management plan and oversees its implementation -Proposes to the basin water council the number to be considered as "a low expressions amount" for exemption of use right permit; Establishes the mechanism and suggests the price charged for water use -Problem: -*de fact* does not control water resources. It does not issue the permit for water use (*outorga*). In federal rivers, ANA grants the use right, and state agencies issues the permit for water body in the state

A watershed agency will only exist if its basin can financially support the agency with the resources obtained from water use payment [1997 BWP, Art. 41, Art. 43]. ANA is not the specific agency for the *São Francisco* River Committee, it is the national one. It has been playing an important role in the case of this national river and in the new framework for water resources management. For example, it has granted water use right. A river basin committee's working area is one watershed, sub-basins or continuous basins [1997 BWP, Art.37]. Committees with jurisdiction over federal rivers, such as the *São Francisco*, require the Water Resources National Council and the Brazilian president's approval for their creation [1997 BWP, Art. 35, VII; Art.37].

The watershed committee is a governmental entity, but it does not have a legal juridical personality. It is not seen as an independent entity. It has no enforcement power. It has no penalty power. It can force no one to follow the rules regarding achieving both water quality and quantity's specifications. It is a member of the national water resources management system, but federal and state's members of this new system are the ones monitoring and assuring compliance (1997 BWP, Art.29, II; Art. 30, I). For example, the National Water Agency maintains a water quality monitoring system, but the committee has not charged polluters.

The National Water Resources Management Plan. The 1997 Water Policy mandated the existence of long-term management plans for watersheds, states and the nation to guide policy implementation [Law# 9,433, Art.6, Art. 8]. The National Water Resources Management Plan includes an assessment of existing water resources, scenarios of future demands and alternatives to supply the needs of the different sectors. It also identifies possible sources of conflicts. The Water Resources Secretary of the Environment Ministry – SRH-MMA coordinated the creation of the plan whose elaboration included the participation of federal and state agencies representatives, NGOs and users. In addition, the National Water Agency helped to create and oversees the

implementation of the plan (SRH/MMA 2006). In 2006, the Water Resources National Council approved the national plan for the period of 2005-2020 [CNRH Resolution# 58 of 2006, SRH/MMA 2006]. The National Plan divided the nation into twelve hydrographic areas, including the SFR basin, and into fifty-six planning zones [CNRH Resolution# 32 of 2003, SRH/MMA 2006].

The SFRB Water Resources Management Plan. According to the 1997 Water Policy, the basin committee is in charge of planning the use of the water resources of the watershed. A watershed water agency linked to a committee elaborates, submits to committee's approval, and implements the watershed management plan. But, because the agency of the SFR did not exist in the period of creation of its plan, in the *Velho Chico*'s case the process took a different direction. A committee deliberation [CBHSF Deliberation# 3 of 2003] defined the guidelines for the SFRB Water Resources Management Plan. A group led by the National Water Agency – ANA wrote the plan for the SFR, which included data from previous studies of the basin such as the one that had just been undertaken by ANA/GEF/PNUMA/OAS. The group that created the plan included the development Company for the Valley – CODEVASF, and state and Federal District water management agencies. Technical and regional consulting chambers of the CBHSF oversaw the making of the document [CBHSF Deliberation#3 of 2003, CBHSF 2004].

The CBHSF approved its first ten-year water resources management plan in 2004 [CBHSF Deliberation# 7 of 2004]. The CBHSF took the decision after holding two phases of public meetings in different municipalities of the valley and in capital cities of the basin's states to allow public inputs (CBHSF 2007, CBHSF 2004).[16] The comments from the public predominantly focused on restoration measures and upon water allocation (CBHSF 2004). In addition to the inclusion of public comments into the plan, the CBHSF has

[16] Public meetings took place in: *Belo Horizonte*-MG, *Pirapora*-MG, *Ibotirama*-BA, *Juazeiro*-BA, *Maceió*-AL, *Santa Maria da Vitória*-BA, *Salgueiro*-PE and *Aracaju*-SE. A forum took place in *Brasília* (CBHSF 2004).

already suggested further reviews to adjust the plan in response to committee's deliberations [CBHSF Deliberation# 7 of 2004].

This was a change from the past. The plan incorporated holistic and integrated (water and land) approaches. It focused on quantity (e.g., river discharge) and quality issues (e.g., water pollution), as well as upon the river's health and integrity (e.g., ecological discharge/ functional capacity). One objective of the plan was to achieve the environmental sustainability of the basin respecting its carrying capacity as service provider, including waste assimilation and efficient use of non-renewable resources. The plan also included an assessment of the river basin, scenarios for water uses, instruments of the 1997 water policy, and alternatives for the restoration of the basin besides actions to implement them (CBHSF 2004). The revenue from water use in the watershed plus governmental support will finance the implementation of the plan.

Revitalization. The need of the use of the SFR's water resources for new endeavors such as the inter-basin water transfer project and new hydropower stations led to the idea of the revitalization (CODEVASF 2003).[17] In 2001, the Brazilian President used a decree to create a project for the protection and restoration of the socio-environmental conditions of the *São Francisco* River Basin environment. The legal instrument mandated participation of the various levels of government and of the civil society in the creation and implementation of the Revitalization Program. The main objective of the Revitalization project was to improve the volume of water the watershed can supply. The decree created a committee to manage the Revitalization project with the Environmental Ministry – MMA in charge of coordination [Decree no number of 05 Jun 2001, Art.1, Art. 2]. MMA has the support of the Integration Ministry, and other ministry, federal and state agencies. The Committee of the *São Francisco* has also being part of it

[17] Revitalization meaning "the process of recovery, conservation and environmental preservation through implementation of integrated actions that promote the sustainable use of natural resources, improvement in socio-environmental condition of the basin and the increase in water quantity and quality for multiple uses" (CBHSF 2004, 196).

to assure compliance with the river's management plan (CBHSF 2004). The program was initially included in the Brazilian Multiple-year Plan – PPA 2004-2007 which guided the actions towards the development of the nation (CBHSF 2004). But, the timeframe of the restoration scheme is of twenty-years. From 2004-2006, environmental recovery actions received about one hundred million dollars (MIN 2010). CODEVASF implemented most of the projects. The Revitalization Program has undertaken reforestation, erosion control, and improved sanitation in cities of the valley to enhance water quality [Decree no numbered of 05 Jun 2001, Art. 5; CBHSF 2004; MIN 2010).

The decree [Decree no numbered of 05 Jun 2001, Art. 3°] required the inclusion of the following components in the restoration scheme: pollution removal, soil conservation, human adaptation to drought prone environments, reforestation and recovery of riparian forests, water resources management and monitoring, solid waste management, environmental education and conservation and preservation zones. The project was composed of five core areas of actions: (1) management and monitoring, (2) strengthening of institutions and environment, (3) natural resources protection and recovery, (4) quality and environmental sanitation, and (5) sustainable economies (SRHU-MMA 2007). The program was broadly associated with the *Transposição*. Indeed, while some affirmed that it was a way to allow the inter-basin water transfer scheme to take place, others believed that the basin was going to receive one project or the other.

The Influence of Other Federal and Regional Agencies

Historically, various agencies have influenced the management of the *Velho Chico* and other water resources in the Northeast of Brazil. This section described those institutions based mostly upon a literature review. Nevertheless, it also followed leads from my interviews. In the context of droughts, and hydropower and irrigation capabilities as described in Problem Orientation I, no doubt exists that the history of water resources

management in the valley would include institutions mostly linked to those uses (Table 4.3).

Table 4.3. The History of Water Management in the Valley

Name [and Brief Description]	Date of Approval	Objectives and Accomplishments
IOCS/ IFOCS/ DNOCS [agency against droughts]	1909	-fought against the negative effects of droughts and floods -undertook studies -built water reservoirs, wells, roads, work programs in the Northeast (e.g., drought relief programs) -established aquaculture programs in water reservoirs
Diretoria de Águas/ *Serviço de Águas/ Divisão de Águas/* DNAE/ DNAEE/ANA and SRHU-MMA [water agency]	1933	-Implemented measurement stations -monitored uses -functions now undertaken by ANA and SRHU-MMA
CNAEE/DNAEE/ANEEL [energy agency]	1939	-created regulations for the 1934 Water Code -tasks undertaken today by ANEEL
DNOS [sanitation agency]	1940	-jurisdiction in the entire nation -sanitation works -drainage works -pollution and erosion control -ended in 1990
CHESF [*São Francisco* Hydropower Company]	1945	-hydropower company for the valley -explored the hydropower potential -built and manages eight hydropower stations in the *São Francisco* River -undertook investigations
CVSF/SUVALE/CODEVASF [*São Francisco* Valley Development Company/Agency]	1948	-development agency for the valley -planning and implementation -studied the valley
CEMIG [*Minas Gerais* State Hydropower Company]	1952	-hydropower company in *Minas Gerais* also working in the valley -explored the hydropower potential -oversaw the construction and manages *Três Marias* hydropower station
BNB [Northeast Development Bank]	1952	-financed the development of the Northeast. -an office of BNB led to the creation of SUDENE -undertook investigations
SUDENE/ADENE/ SUDENE [Northeast Development Superintendence]	1959	-development superintendence of the Northeast -studied, planed and implemented the development of the northeast region -sought to reduce the disparity among the Northeast and other regions of the nation

After the 1930s the state played a strong role in the modernization of the nation, part of a worldwide trend towards increasing state involvement in the economy. The governmental economic policy was based upon the 1930s' idea of national development (*Nacional-desenvolvimentismo*). From post-WWII to the beginning of the 1960s, the nation imposed restrictions on imported goods following an "import substitution model." During early 1960s and 1979, the "export substitution model" dominated and was extended until 1989 (Silva 2003). Brazilian development based upon industrialization and urbanization required vast supplies of electric power. Still, the nation has also never stopped being an agro-exporter country. From 1960 to mid-1980s, the state also instigated and regulated the modernization of agriculture (Favareto 2006).

Regarding the Northeast, governmental strategies had two directions. During the 1877-79 and 1951 droughts, alternatives implemented for that region of Brazil followed the technical *hydraulic approach*: engineering solutions to provide access to water. The federal government funded the construction of water reservoirs in different parts of the region. Nevertheless, not many people of the basin had access to the precious resource even though the *São Francisco* River was still one among few steady sources of water. It provided very obvious, 'close-by' forms of physical and spiritual sustenance for the ones in riparian zones. After the 1950s, the purpose of federal policies for the Northeast went beyond mitigation of the consequences of droughts and started to focus on other issues such as economic development, guided by an economic approach, an extractive and exploitation-based use of the *São Francisco* River emerged.[18] River and user came to be so 'distant' from one another. The ecosystem services of the waterway, such as electricity, influenced the life of individuals living far away. It created an 'unseen' and

[18] According to Hirschman (1963), the national accounting system, developed in 1950-51, made clear the growing difference between the per capita income of the Northeast and Center-South (Hirschman 1963). This argument was contested later on by Robock (1963) and Katzman (1977), both acknowledged that the data did not support that conclusion, and that the economic position of Northeast in relation to *São Paulo* was not deteriorating as previously thought. Nonetheless, Hirschman (1963), Robock (1963), Katzman (1977) and Goldsmith and Wilson (1991) recognized the intra-regional economic and social disparities of the northeast region of Brazil.

'unperceived', but strong dependence among human beings and the river environment which supplied the electrical power.

Major policies for the SF have been formulated outside of its basin, and the valley has been the site where different rationalities meet and conflict. Goulet (1986) has identified three: the technical, the political, and the ethical. The first plans for the valley initially focused on its waterway possibilities. The study of the basin's navigation capabilities began in 1852 (CVSF 1957). D. Pedro II, Brazil's emperor required investigations as the ones undertaken by Liais in 1852, Halfeld 1852 to 54, and Sampaio *et al.* in 1879. Nevertheless, besides studies, not much was done in effect to improve navigation or for the development of the valley besides minor works to remove sediment and rocks from the river canal (Novaes 1989, Sampaio 2002).

In the 1930s, President Vargas' "New Deal" or the new view for the nation included the *São Francisco* River. The valley was supposed to become "Brazil's economic spine" (Garcia 1938, 1, 27). The watershed would include beside the inland navigable way, roads, and railways to bring to the markets products from the interior countryside. The plan was seen by some as a way of nationalization of the nation's wealth (Garcia 1938). Nevertheless, no one can deny that, the major attraction of the valley was the river. But, in practice again not much was done during the 1930s.

The resurgence of the national importance of the river during the twentieth century was due to the Second World War. In early 1940s, President Getúlio Vargas opened credit for an emergency program for the SFR, the only 'safe' water shipping link between South and North of country during the war (Novaes 1989).[19] The resource allowed the construction of wharves (e.g., *Pirapora*, *Lapa* and *Juazeiro*) and carrying out studies (Silva 1985, Novaes 1989).

[19] The German's U-Boats attacked Brazilian coastal shipping (McCann 1995).

In the late 1940s and early 1950s the river glowed again in the public imagination for other uses besides navigation. Electricity production became a reality. Large-scale electricity stations started to be built in 1948. As an example, industries from other parts of Brazil planned to move to the future power abundant metropolitan cities of the Northeast, such as *Recife* and *Salvador* region, even before the opening of the new SFR's power station, *Paulo Afonso* as reported on The New York Times (15 Nov 1953, F5). Besides that, states such as *Pernambuco* also provided tax benefits such as "ten-year exemptions from taxes on capitalization" for any new industries (The New York Times 15 Nov 1953, F5). Those facts increased the demand for the power from the *São Francisco*.

IOCS/IFOCS/DNOCS. In 1909, President *Nilo Peçanha* established the *Inspetoria de Obras Contra as Secas* – IOCS to have an institutionalized response to the negative effects of repeated droughts in the Northeast of Brazil. From 1919 to 1922, attention to the problem of water scarcity increased as the result of the presence of a Northeasterner in the presidency, *Epitácio Pessoa* (Hirschman 1963). The IOCS became the *Inspetoria Federal de Obras Contra as Secas* – IFOCS in 1919. The new president expanded the agency's budget. IOCS/IFOCS directly or through sub-contracts undertook studies, and built infrastructure projects, such as railroads and roads, bridges, dams, water reservoirs, wells, public water supply systems and ports. It also developed meteorological, hydrological, geological and botanical studies of the Northeast (Frota 1983, DNOCS 1985, DNOCS n.d.a). Road construction had two purposes: to move in relief supplies and to allow out-migration, especially during drought periods (Hirschamn 1963). But after 1922, the level of work implemented by IOCS/IFOCS in the region alternated between non-existent and minimal until the President *Vargas* government in the 1930s (Hirschamn 1963). As already described, the 1934 Constitution stipulated that at least 4% of the federal income revenues would have to be used to combat the effects of droughts in

the Northeast of Brazil, being 1% for emergency relief programs and 3% for the implementation of a long-term plan.

After 1936, IFOCS and later on DNOCS were in charge of working in the area established by presidential decree, as the *Drought Polygon* described in the drought section (CEAS 1971). The area partially included the SFRB. In 1938, IFOCS created a committee to plan and implement works along the SFR under the agency's influence. The committee undertook studies of the *Itaparica* Falls' area and the region of *Juazeiro* (Zarur 1946).

In 1945, IFOCS became the *Departamento Nacional de Obras Contra as Secas* – DNOCS (DNOCS n.d.a). DNOCS and its predecessors played an important role in the implementation of the *hydraulic* approach. Nonetheless, infrastructure alone was not enough to solve the problems of the region. The problem required a new approach. The Northeast Development Superintendence – SUDENE was put in the control of the new one. This economic approach dominated after the 1950s.

DNOCS' jurisdiction over drought related issues changed over time. In 1948, the creation of the CVSF, the commission in charge of development of the *São Francisco* River Valley placed DNOCS's work for the watershed under its coordination. In 1959, the creation of SUDENE also subordinated DNOCS's actions, in this time, for the entire Northeast.

The history of DNOCS and its predecessors presents four phases characterized by different priorities. The institution's work started with pioneer studies of the area followed by the improvement of transportation and construction of large reservoirs and wells. During the third stage DNOCS continued building large water reservoirs and then, promoted their use for agriculture, hydropower generation, aquaculture and fishing, and leisure activities. In the fourth period, DNOCS intensified its focus on irrigation and colonization of humid lands, and the need for research institutions to improve agriculture

following national programs for the Northeast, such as National Integration Program – PIN and the Land Distribution Program – PROTERRA (Souza 1979). As already mentioned, DNOCS's works also included the introduction of aquaculture and irrigation schemes in federal water reservoirs (DNOCS 1985).

General approaches to remedy the drought problem in the Northeast incorporated food donation programs, temporary work systems (*frentes de trabalho*) and migration schemes to urban zones and/or other regions of Brazil (CEAS 1971). But, DNOCS and its predecessors were accused of implementing such improvements on private lands to benefit members of the economic and political ruling classes of the Northeast (Oliveira 1981).

In 2010, the DNOCS was under the jurisdiction of the Integration Ministry. It has still worked against the effects of droughts, and floods as well. DNOCS heads up the construction of public federal reservoirs and other water related infrastructure such as canals in the semi-arid region. It also is in charge of governing such infrastructure when other arrangements do not exist, such as the watershed-based management and another governmental company or agency, such as hydropower corporations. In the *São Francisco* River Basin, the federal reservoirs were under the jurisdiction of the CODEVASF, except the reservoirs of the *São Francisco* power stations which were overseen by CHESF or CEMIG.

Water Division (*Divisão de Águas*)/DNAE/DNAEE/ANA and CNAEE/ANEEL. The history of national water and energy regulatory agencies dates back to 1920, as a hydropower committee of the Agriculture, Industry and Commerce Ministry. In 1940, an outgrowth of that committee became the *Divisão de Águas*. The *Divisão* played an important role regarding water resources studies, such as recording hydraulic data series (Azevedo 1968, vol. 1). For example, it implemented instruments for the measurement of river discharge and precipitation complementing the data already recorded by private

institutions and of the *Serviço Geológico e Mineralógico* (Azevedo 1968, vol. 1). The *Divisão* also analyzed requests for water use (Tavares *et al.* 2006).

Besides the existence of this water related governmental body, a new legal framework created the need for an additional institution. The 1934 Water Code required the establishment of a national water and energy council to among other things, assess the country's hydropower potential and to embody the highest level of conflict resolution [1934 Water Code, Art. 200]. The Law-decree# 1.285 of 1939 created the National Water and Electric Energy Council – CNAEE (Pompeu 2006).

The *Divisão* of the Agriculture Ministry monitored and implemented CNAEE's policy [Law-decree # 4.295 of 1942]. But, the majority of the CNAEE's work was related to hydropower. According to Granziera (2007a), the 1934 Water Code has been mostly regulated for hydropower. The council initially linked to the nation's presidency played a consulting and oversight role in the matter of hydropower and energy. The CNAEE was in-charge of creating and submitting the Water Code's regulations to the head of the executive government (Pompeu 2006). Besides, it provided water use permits, oversaw and proposed measures for the rational and economic use of energy, also establishing priority among uses when demand surpassed supply. In 1960, after the creation of the Mining and Energy Ministry the CNAEE and the *Divisão* became institutions subjected to this ministry.

The Law# 4,904 of 1965 created the National Department of Water and Energy – DNAE replacing the *Divisão*. The DNAE was then in charge of ensuring implementation of the 1934 Water Code (MME *et al.* 1983a). In 1968, DNAE became the National Department of Water and Electric Energy DNAEE [Decree# 63,951 of 1968], also under the umbrella of the Mining and Energy Ministry, in charge of both water and hydropower issues. CNAEE became extinct in 1969 and was incorporated by the DNAEE [Law-Decree#689 of 1969]. In addition, ELETROBRAS, Brazilian Electricity Corporation [Law#

3,890-A of 1961) also replaced activities of the CNAEE in the coordination of electric power systems.

In 1977 the DNAEE was in charge of planning, overseeing and undertaking water related studies in the nation; and of overseeing, monitoring and controlling uses which altered water regime and electrical power [Administrative Rule MME# 234 of 1977). The analysis of the viability of water projects to provide use grants (e.g., authorization and concessions) for withdrawal, transferences and effluent discharge was one among many jobs of DNAEE (MME 1982).[20] DNAEE managed water resources uses at national level. In 1979, the DNAEE Resolution# 99 mandated that projects needed to meet ecologic and environmental requirements (MME 1982). But, lack of political will at the top led to failure in implementation.

The available hydrological data for the *São Francisco* resulted from the work of DNAEE and its predecessors. Despite DNAEE's jurisdiction over national's water, other institutions could also be in charge of authorizing withdrawals of public waters. For example, the Extraordinary Minister for Irrigation authorized withdrawal for irrigation (CODEVASF *et al.* 1986).

DNAEE's works were shared among National Electric Energy Agency – ANEEL, National Water Agency – ANA and the Urban Environment and Water Resources Secretary – SRHU-MMA. In 1996, the Law# 9, 427 [Art. 34, §4°] created ANEEL and authorized the end of DNAEE with the approval of ANEEL's first internal rules. The termination of DNAEE took place in 1997. ANEEL focuses on electricity related issues. In October 6, 1997 the Presidential Decree # 2,335 formed ANEEL, linked to the Ministry of Mining and Energy. The Table 4.2 described ANA and SRHU, both entities are under the environmental ministry jurisdiction and replaced DNAEE's tasks in water resources management.

[20] Concession is for the public good and authorization for private benefit.

ANEEL regulates and oversees the production, transmission, distribution, and commercialization of electric energy. It is supposed to regulate the use of hydropower stations' reservoirs in accordance with the 1997 Water Policy. It also collects the revenue generated by the use of water resources for hydropower generation [Decree# 2,335 of 1997].

DNOS. The National Department of Works and Sanitation – DNOS has its roots in a committee of the last decade of the 1800s in charge of studying and providing solutions for the drainage of the lower lands, *Baixada*, of *Rio de Janeiro* for agricultural purposes (Carneiro 2003). By then, it only headed up sanitation works in the Federal District (Silva 1998). In 1940, the committee became DNOS and its jurisdiction was extended to the entire nation though with emphasis upon the initial operational area. DNOS headed up works from drainage to sanitation, from water pollution to erosion in urban and rural zones (Carneiro 2003). In the valley, for example, DNOS undertook investigations of flood control (Biswas *et al.* 1998), and irrigation. Its legacy contributed to the current debate of the inter-basin water transfer together with private companies and the U.S. Bureau of Reclamation. Their report analyzed technical, economical and social viability of the project. It was published in 1985 (Carvalho 1994). President Fernando Collor ended DNOS in 1990 [Law# 8,029 of 1990, Art. 1]. DNOCS replaced DNOS in some areas.

CHESF and CEMIG. Two hydropower companies control power generation and the flow of Velho Chico's water: CHESF and CEMIG. In 1921 the Agriculture Ministry undertook the first topographic study regarding the use of *Paulo Afonso* Waterfall for hydropower generation. But, only in the 1940s the federal government decided to build such project (Souza 1955, Carvalho *et al.* 1989). Previous studies had identified the hydropower capacity of the river.[21] In 1945, President Vargas authorized the creation of the *São Francisco* Hydroelectric Company (*Companhia Hidro Elétrica do São Francisco*)

[21] These investigations included the *Comissão Hidráulica* in 1879 (Sampaio 2002), The American Technical Mission in 1943 (Robock 1963) and CVSF in 1951 (CVSF 1951).

– CHESF by the Agriculture Ministry to exploit the electrical generation potential of the *Velho Chico* [Decree Law #8.031 of October 3, 1945]. Public and private resources owned the company's stocks. CHESF's jurisdiction was initially set as a 450 kms radius centered on the first station to be built in *Paulo Afonso* Waterfall, in the lower-middle *São Francisco* River for a fifty-year period [Decree# 19.706 of October 3, 1945].[22] CHESF's creation only took place officially with the first meeting of its general assembly in 1948 (CHESF 1998). Since then, the company has built and managed hydropower infrastructures, and transmitted energy to sub-stations.

In 1952, President Juscelino Kubitscheck created CEMIG. It is also still in charge of the management of *Três Marias*. The most upstream barrier which holds back Chico's water was conceived for multiple purposes, as to allow the management of flooding, improve navigation during droughts, and make possible large-scale irrigation and hydropower generation (Serebrenick 1961, Observador 1962). The sub-product electricity became the main creation (Silva *et al.* 2000). The state of *Minas Gerais* controls the mixed-capital enterprise.

CVSF/SUVALE/CODEVASF. In 1948, Law# 541 created the *São Francisco* Valley Committee – CVSF. CVSF was supposed to be a Brazilian version of the Tennessee Valley Authority – TVA (Cavalcanti 1988).[23] The 1946 Constitution had established that at least 1% of the tributary income was to be used for the development of the SFRB. The CVSF was in charge of administering that effort.

CVSF was financially and administratively an autonomous institution linked to the presidency of Brazil [Law# 541 of 1948]. However, it was not free from political influence (Marques 1958d, Ferreira 1958). "CVSF effectively had to request appropriations on an annual basis, which weakened its independence" (Katzman 1977:134). The Brazilian

[22] In 1964, the Decree# 54,160 increased CHESF's radius to 700 kms centered in Paulo Afonso station. Today, CHESF also manages power stations outside of the valley.
[23] In 1944, Apolônio Sales, the Brazilian Agriculture Minister visited the Tennessee Valley to assess the dams and see how to implement those infrastructures in Brazil. In 1946, a TVA engineer went to the SFR basin. In 1949 the President Eurico Gaspar Dutra visited TVA too (Lilienthal 1972).

President was in charge of selecting the location of CVSF's headquarter and of choosing the top management body, composed initially of three directors, one being the superintendent [Law# 541 of 1948].

CVSF's objectives included: (1) creation of a plan for the economic use of the *São Francisco* River Valley; (2) implementation of the plan after congressional approval; (3) support of displaced populations resulting from CVSF's work in the basin; and (4) coordination and monitoring of the efforts of other agencies working in the basin, as for example CHESF [Law# 541]. Hydropower was not the only focus of CVSF's projects. But, it was an important one in a period of time when the 'developing' northeast and the nation were increasing demand for electrical power. The lack of an economically feasible alternative source of energy in the area, such as coal-fired, shifted attention towards the hydraulic forces of the river.

The major office of CVSF was located in the capital of the nation. In addition, CVSF had administrative, field, and irrigation offices in different areas of the watershed, such as in *Bom Jesus da Lapa, Juazeiro, Pirapora, Petrolina, Penedo,* and *Guanambi* [Law#541 of 1948, Decree# 29,807 of 1951, Novaes 1989].

In December 1950, the Director-Superintendent of CVSF submitted a general plan for the valley for congressional approval (Novaes 1989, CVSF 1951). But the final version of the plan (1951-1955) was only approved in 1955 [Law# 2,599 of 1955, Art.18]. A Bahia deputy, Novaes (1989) mentioned that, the General Plan took into consideration, and sought to address, issues uncovered and based upon information on local's way of life, complaints and demands collected throughout a two-year period of investigation. That was probably one of the reasons CVSF were able to work on projects that benefited the local populations. CVSF's goal was to implement the general plan during four five-year plans (CVSF 1951). CVSF also became the leading agency of projects approved before its creation, such as the 1947 Emergency Program, which besides improvement in the

river's navigation proposed the construction of power plant stations, irrigated fields and hospitals (CVSF 1951, CVSF 1957).

In practice, CVSF sought to address the problems of the valley from a broad perspective. CVSF built regional hospitals, health clinics and maternity hospitals in *Pirapora, Bom Jesus da Lapa, Juazeiro, Petrolina* and *Penedo* (Serebrenick 1961, Novaes 1989). CVSF built and left them under the management of the National Health Foundation – SESP. CVSF partially or totally built, financed and oversaw the construction of power stations and electricity distribution network (SUVALE 1968a). It implemented infrastructure projects, such as water treatment plants, power stations, radio stations, hospitals, roads, bridges, airports and land fields, irrigation zones; and undertook important studies, namely cartography and hydrology (Serebrenick 1961, SUVALE 1968a).[24] It built or improved ports and river front structures, namely in *Pirapora, Lapa, Petrolina* and *Penedo*. CVSF worked to improve rain water's drainage, such as in the case of *Penedo* (Serebrenick 1961). It carried out important improvements for the valley.

In the first and second five-year plan CVSF built the *Três Marias, Pandeiros* and *Correntina* power stations. In 1956, transport, energy and health accounted for 73% of the resources the five-year plan used for that year. In 1957, the construction of *Três Marias* contributed to almost one-fourth; and the figure was almost half of the resources spent from 1958 to 1960 (Serebrenick 1961).

The CVSF was not completely unaware of ecological issues and environmental protection. The bylaw of the CVSF of July 1951 [Decree# 29,807], the twenty-year general plan and the law which approved it suggested and mandated conservation measures [Law# 2,599 of Sep 1955; CVSF 1958a]. They required improvement in water and sanitation systems, protection of riparian regions against the effects of floods and

[24] In 1968, the valley has 60 airports and 12 commercial routes (SUVALE 1968a).

droughts; and conservation of plant and animal species, as well as reforestation [Law#2,599 of 1955, Art.1, j, o; Art.8; Decree# 38, 969 of 1956].

Critics of CVSF stressed the existence of political control of the agency. The new approach proposed for the successor agency, the SUVALE, would attempt to reduce paternalistic and 'pork barrel' scheme of management which resided in CVSF and in many other governmental agencies' institutional memory. For example, a reporter affirmed that one political party controlled the CVSF in *Bahia* and another one in *Minas Gerais* in 1958 (Ferreira 1958). It is true that due partially to political influence, CVSF ended up benefiting some municipalities more than others as even mentioned in one of its own reports (Serebrenick 1961). CVSF was also subjected to local politics and conflicts among local power figures, such as the mayors and CVSF or subcontracted agencies and corporations (Marques 1958d). In 1967, after the end of CVSF, other agencies headed up its tasks. CHESF was then 'independently' in charge of electricity issues, FRANAVE led navigation and SUVALE organized everything else (CODEVASF 1985).

In 1967, the Law-decree# 292 terminated the CVSF, which existed for a twenty-year period, and created the Superintendence of the Valley – SUVALE in charge of promoting, coordinating and overseeing the development of the SFR valley [Law-decree # 292 of 1967]. Politically, SUVALE was linked to the Interior Ministry. In theory, it was financially and administratively independent. In practice, it was a semi-autonomous institution, though differently from CVSF which had been connected to the presidency.

In 1967, the United States Bureau of Reclamation had recommended in an assessment report the creation of SUVALE as a part of a plan for the efficient use of the valley's water and land resources (USBR and SUVALE 1974a). SUVALE had offices in and outside of the valley. The headquarters was located at the Federal District. It had six regional offices: *Belo Horizonte, Pirapora, Bom Jesus da Lapa, Irecê, Juazeiro* and *Propriá*; plus representative offices and sub-agencies (USBR and SUVALE 1974a).

Agronomists and engineers accounted for almost half of its technical personal (USBR and SUVALE 1974a).

The resources for the CVSF resulted from the tributary income article mandated by the constitution. In the case of SUVALE, the federal government funded it (Novaes 1989). The Interior Minister was in charge of suggesting the name and the President of Brazil of appointing SUVALE's superintendent and a proxy (SUVALE 1968c). The creation of SUDENE, the Development Superintendence for the Northeast reduced SUVALE's autonomy as it had done to CVSF. The plans for the valley were then part of SUDENE's strategy for the entire region [Law# 4,869 of 1965].

The management council approved SUVALE's bylaw in 1968 [Resolution# 76 of 1968]. SUVALE sought to promote the economic use of the natural resources of the valley and to create rural development and investment's possibilities, namely industry, agriculture and herding activities. The regulation and management of the use of the flow of the SFR and its tributaries were also SUVALE's objectives. Based mainly upon hydropower potential and soil production's capabilities, SUVALE and SUDENE chose the zones for investment that included *Petrolina* and *Juazeiro* in the lower-middle and flooded zones in the lower-SFR (SUVALE 1970a). It also focused on seven program-areas: (1) to develop the knowledge to the multiple use of the basin's resources; (2) to use the resources economically for multiple objectives; (3) to promote herding and agriculture development; (4) to support and promote private initiatives within the valley; (5) to directly or indirectly implement hydro works; (6) to manage the water use; and (7) to build, manage and explore hydropower infrastructure system (SUVALE 1970a).

CVSF had a wider view and area of work than SUVALE did. SUVALE's operational area *de facto* did not include the entire valley, shifting the view from holistic development and programs to specific zones (Novaes 1989). Implementation of pilot-irrigation programs in the selected areas was its major objective. It sought to promote

private agro-industries throughout examples demonstrating the possibilities of such forms of production in the valley (SUVALE 1973b).[25] These actions set in motion forces that created future problems in the valley.

SUVALE's bylaws included environmental protection considerations. Section I, described the need of promoting and undertaking studies of the soil, ecology of the area, and expansion of works on vegetal and animal protection (SUVALE 1968c). In 1972, SUVALE started a program to restore the ecology of the valley (SUVALE 1973b). SUVALE promoted fish restocking programs (CODEVASF 1992). It reforested *Três Marias* Reservoir's riparian areas (SUVALE 1973b). But the agency also proposed such not so environmentally sound practices as the use of exotic species for reforestation, and for the development of grass lands in the savannah biome (SUVALE n.d.g., SUVALE 1968c). SUVALE sought alternatives for rural development.

In the matter of water, SUVALE was supposed to suggest the price of a cubic meter of water based upon operational costs (SUVALE 1968c). The practice of charging only for infrastructure still holds in irrigation projects in the valley. SUVALE, in partnership with federal and state agencies, implemented public water treatment and supply systems in municipalities of the valley (SUVALE 1973b).

Differently from CVSF which had existed for twenty years (1948 to 1967), SUVALE only lasted from 1967 to 1974. SUVALE introduced a more business-oriented approach to

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[25] In 1972, President Medici used a Decree# 1,207 to create a special program for the *São Francisco* Valley – PROVALE. Several ministries, Agriculture, Interior, Transportation, and Mining and Energy were responsible for the implementation of the program, for which financial resources were included in the national budget. According to Novaes (1989), the PROVALE complemented SUVALE's narrow approach if compared with CVSF working areas. PROVALE also provided resources for *Sobradinho* (Novaes 1989). PROVALE sought the integration among different institutions and spheres of the government working in the valley (Souza 1979). Irrigation was an important component of this program which sought to accelerate the development of the basin (Carvalho 1980). Ministries (e.g., Agriculture and Interior) and entities (e.g., CODEVASF, DNOCS, SUDENE, DNOS) undertook irrigation projects in the Northeast. Besides PROVALE, several other programs were important for agriculture in the basin and in the Northeast. The 1974 program POLONORDESTE attempted to transform traditional into modern agriculture (Miranda 1990b, Chilcote 1990). In 1976, project *Sertanejo* aimed to assist small and medium sized producers of the semi-arid zone (Miranda 1990b, Chilcote 1990). The 1981 Provárzeas Program attempted to use the flood plains, draining and irrigating them, for agriculture (Souza 1990).

the development of the valley, providing credit, technical assistance and training, and attracting private investments to projects in the basin (SUVALE n.d.h). SUVALE sought to use the resources of the valley, namely land and water for the development of socio-economic infrastructure, irrigation and herding (SUVALE 1970a). These objectives would also only be made possible with the control of the flow of the SFR and its tributaries.

In 1972, David Lilienthal, President of the Development and Resources Corporation, a United States consulting company, signed an accord to help the Brazilian Government develop the resources of the SFR valley. The creation of a new watershed development agency was one of his recommendations (Novaes 1989, Neuse 1992). He also suggested that if "for no other reason, a regional agency would be justified solely to allocate and regulate the use of the precious water resource in the Valley" (Development and Resources Corporation 1974a, II-6). The agency should be like a business, autonomous and accountable for its decisions and actions, sharing responsibilities and subcontracting to other agencies when necessary. The plan also suggested public engagement in programs' implementation, meaning local government and people (Development and Resources Corporation 1974d).

In 1974, the Law# 6,088 created the *São Francisco* River Development Company (Companhia de Desenvolvimento do Vale do *São Francisco*) – CODEVASF (CODEVASF 1992). CODEVASF is a governmental corporation with resources from the federal budget (Development and Resources 1973). It has a narrow focus, being in charge of the development of agriculture, animal raising and agro-industry in the valley, especially irrigated agriculture (SUVALE n.d.h.). CODEVASF was not conceived of as an alternative to integrated management of the valley's resources (Neuse 1992).

Despite its narrow focus, it does not mean that the company has not worked in areas outside of its jurisdiction. As examples, CODEVASF has worked in settlement projects outside of the valley such as in *Ceará*, *Piauí* and *Maranhão* (CODEVASF 1992).

CODEVASF has dug wells, built smaller dams and canals for public water supplies (CODEVASF 1992).

CODEVASF initially managed the irrigated zones, but it sought to shift such management onto cooperatives and associations (Novaes 1989, CODEVASF 1992). The Brazilian federal government throughout CODEVASF received innumerable loans for agricultural projects in the basin, from the World Bank, from the Inter-American Development Bank and the Japanese (Overseas Economic Cooperation Fund - OECF) and from Hungarian government (Novaes 1989).

A CODEVASF's staff had early on called attention for analysis of the effects of the construction of reservoirs, and the pollution resulting of the use of fertilizers and pesticides from observations of environmental problems in irrigation projects as early as 1975 (Vianna 1975). But only in 1986, did CODEVASF create an environmental department (*Coordenação de Meio Ambiente*), and a water resource and environment division (Divisão de Recursos Hídricos e Meio Ambiente) in 1991 (CODEVASF 1992). The later department also has dealt with the required environmental assessment report (CODEVASF 1992).

In 2000, CODEVASF incorporated into its jurisdictions the *Parnaíba* Valley in *Piauí* and *Maranhão* [Law# 9,954 of 2000], and the *Itapecuru* and *Mearim* Valleys in *Maranhão* in 2010 [Law# 12,196 of 2010]. Interviewees' perspectives on CVSF/SUVALE/CODEVASF are varied. Interviewees have linked the importance of CVSF to the construction of dams, despite all its problems (Historian/Professor, PC, 17 May 2007, Pirapora-MG).[26] The benefits of CVSF's works have been felt by many of the valley's population. It built hospitals, fought alongside with other federal agencies (e.g., SESP, DENERU, *Serviço Nacional de Malária*) against diseases such as malaria in *Pirapora* (Historian/Professor, PC, 17 May 2007, Pirapora-MG). Despite the fact that some will

[26] PC meaning Personal Communication

recognize that it helped one state or area more than others, it assisted the population of the valley (Marques 1958d). CVSF constructed roads and ports (Historian/Professor, PC, 17 May 2007, Pirapora-MG). It built airports and runways (Historian/Professor, PC, 17 May 2007, Pirapora-MG, SUVALE 1968a). By, December 1968, CVSF had improved the port area in *Pirapora*, the riverfront and religious site in *Bom Jesus da Lapa*; the port and urban area of *Juazeiro*, *Petrolina*, and Penedo (SUVALE 1968a). It had linked municipalities and states through roads (SUVALE 1968a).

CVSF worked alone or with federal (e.g., FSESP) and state agencies (e.g., DSE-PE, CESAL-AL, COMAG-MG and DES-GO) to provide water treatment and improve public supply systems (SUVALE 1968a). After construction of the infrastructure, accords between the Federal Health agency and municipalities, led to the creation of Water and Sewage Autonomous Systems (*Serviço Autônomo de Água e Esgoto*) – SAAE. CVSF also worked with SUDENE, the Northeast Development Superintendence, drilling wells and building small dams (SUVALE 1968a).

BNB and SUDENE. This section below described the importance of two institutions which directly did not manage the water of the valley, but strongly influenced the use of the hydro resources.

In 1952, President Vargas had established a new financial entity to stimulate the development of the northeast region, the Bank of the Northeast of Brazil – BNB (CEAS 1971). It used resources from the emergency fund for the Northeast assured by the 1946 Constitution (Robock 1963, Souza 1979). In addition, the mixed public-private entity employed resources from international banks, from fiscal incentive programs, from the sale of shares, and from the federal government (Souza 1979). BNB initially provided loans for agricultural and industrial sectors (Robock 1963, Kartzman 1977). The bank has funded programs in agriculture, ranching and agro-industry; and has implemented programs to provide hydropower connections to rural zones (Araújo Filho and Queiroz 1987).

In 1956, President *Juscelino Kubitscheck* followed the suggestions of the BNB and created a working group, to outline possible alternatives for the development of the Northeast. In 1959, the group published its first report ("*Uma Política de Desenvolvimento Econômico para o Nordeste*"), which included recommendations for a permanent regional development agency, an industrial complex, and modernization of agriculture (CEAS 1971, Santana 1990). Furtado, an employee of the Brazilian National Bank for Development, was in charge of the creation and implementation of this economic approach, whose major objective was to bring-in investments. The Law# 3,692 created the Superintendence of the Development of the Northeast – SUDENE in 1959 (Otero 1969). SUDENE engaged in planning, coordination, cooperation, and enforcement (Santana 1990).

In 1964, at the beginning of two decades of military ruling, SUDENE lost its autonomy of being linked directly to the president of the nation. The agency became subjected of the ministry's jurisdiction (*Ministério Extraordinário para a Coordenação dos Organismos Regionais - MECOR*), which later one became the Interior Ministry (Santana 1990, Otero 1969). The 1967 Constitution removed from SUDENE the resources from the 2% fund to fight against the effects of drought (Santana 1990).

SUDENE's plan for the Northeast envisioned an industrialized sector based upon available hydropower, hiring the abundant workforce, and developing agriculture (Hilton 1963). The outcome would be improved living standards as the result of better incomes, an enhanced food supply and diet due to the consumption of vegetables and milk, and production of raw materials for industry (Hilton 1963). Agrarian reform would be needed to break the structure of underdevelopment. SUDENE proposed an irrigation bill to congress, through President Kubitschek, which included agrarian reform, but it was never approved (Furtado 1989, Furtado *et al.* 1998).

Before SUDENE, plans for the Northeast had been characterized by lack of planning and continuity. "The lack of systematic planning, so frequently lamented, is to be overcome by putting together a vast complex of projects, all of them "interdependent" in some sense" (Hirschman 1963:33). SUDENE was an economic and regional planning agency in charge of coordination of state and federal institutions working in the Northeast (Katzman 1977). For the period during 1960 and 1973, SUDENE created four guiding plans for the development of Northeast. But, starting in 1972, SUDENE's plan for the region (*Plano Regional de Desenvolvimento* - PRD) had to fit with the national one (e.g., *Plano Nacional de Desenvolvimento*). The first National Development Plan – I PND focused on the modernization of agriculture. But, the plan continued to attract industrial investment for urban areas outside of the basin (SUDENE 1979).[27]

Due to developed supporting infrastructure, the capital of states, such as *Recife* and *Salvador*, received the majority of investments and continued to attract new ones (Goldsmith and Wilson 1991). From 1962 to 1989, among different sectors of activity, such as agriculture and ranching, the industrial sector accounted for 53% of the total projects, created three-fourths of total jobs, receiving about 74% of the total of governmental incentives SUDENE managed for the time frame. But, despite the investment, the service sector (e.g., transport, finances and commerce) had the highest share of GDP of the region. For the period of 1960 to 1988, it jumped from 47.5 to 60.9% (Santana 1990). The industrial sector did not absorb a vast number of unemployed and employment was concentrated in major cities. "Developments in the interior were later and less and, in addition, had a higher proportion of modernized rather than new capacity" (Dickenson 1980, 70).

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[27] SUDENE oversaw, coordinated and implemented several programs for the development of the Northeast such as an irrigation program (*Programa de Irrigação do Nordeste* - PROINE), program to support small rural producers (*Programa de Apoio aos Pequenos Produtores Rurais* - PAPP) and their organizations (*Programa São Vicente*) (Santana 1990).

SUDENE undertook or funded studies and implementation of irrigation projects including the ones in the lower-middle-SFR, produced and distributed seeds such as of corn, provided farming machinery and trained the workforce. It built hospitals, financed hydropower and thermal power stations and public water supply systems. SUDENE planned and funded the construction of road infrastructure for transportation systems in rural and urban centers such as *Recife* and *Salvador*. Railroads and ports received a lower priority. The extension of roads in the Northeast increased by 114% from 1960 to 1977. SUDENE improved the communication system, as for example through telephone lines (Otero 1969, SUDENE 1979).

Regarding environmental issue and protection, SUDENE and the national environmental secretary undertook environment studies in the Northeast in late 1970s and supported the creation of states' environmental agencies and secretaries. For example, SUDENE undertook or funded topographic investigations of cities such as *Petrolina* and *Montes Claros* (SUDENE 1979).

SUDENE's approach for planning and implementation of programs was at a regional scale. For example, federal and state agencies' projects had to fit with the objectives laid out by the central organization (Robock 1963). Consequence for the *São Francisco* River was an increasing demand for hydropower and water for irrigation and consequently more dams and power stations.

SUDENE used a top-down approach of decision-making (Robock 1963). Planners from other agencies could provide information regarding the issue of concern, but SUDENE's staff had the power to define the agency's plans and to implement them (Robock 1963, Souza 1979, Santana 1990). Only in 1985 the group included civil society representatives, from agriculture, commerce and industry workers and business people's representatives (Santana 1990). Implementation of activities was not only limited to SUDENE as federal and state agencies played a role too (Santana 1990).

In the 1980s, SUDENE, CODEVASF and the Organization of the American States – OAS undertook an integrated study of the *São Francisco* River Basin to propose guidelines for its development with input from a *São Francisco* River Basin's study committee created in 1979 and which existed until the creation of the watershed-based committee. The Interior Minister requested the plan, the PLANVASF whose objective was to guide governmental actions and trigger private sector works in the valley aiming at increasing income, improving social well-being and increase valley's participation in regional and national economy throughout the efficient allocative use of the basin's natural resources (Santana 1990, CEEIBH 1984, OEA n.d.a., CODEVASF *et al.* 1989).[28] PLANVASF, approved in 1989, focused on agriculture, fishing and aquiculture, transportation, energy, health, sanitation and education programs towards the achievement of predetermined goals (Barbalho 1992). The plan divided the valley into sixteen program areas, and only excluded the areas in *Goiás* and the Federal District because they participation was less than 1% of the basin (CODEVASF *et al.* 1989).

SUDENE became weak over time and moved beyond its initial objectives of centralized planning. Initially conceived of as a planning agency it needed also to be an implementing agency. Besides, the resources to SUDENE did not flow as in the beginning of its history (Souza 1979). In 1990 SUDENE was close to an end. Deliberative council monthly meetings, approval of projects and the fiscal incentive system were temporarily halted (Carli 1996). The institution lasted until 2001, when President Fernando Henrique Cardoso, a neoliberal, replaced SUDENE by a so called independent agency, ADENE. In 2007, during the Luiz Inácio Lula da Silva presidency, ADENE was then extinct and SUDENE created once again [Complementary Law# 125 of 2007]. Its main office is in Recife. It is elaborating a new regional development plan for the Northeast.

[28] Resource employed where and how it is best used.

State and federal agencies continued implementing their own projects for the valley. SUDENE's capabilities to oversee these projects and to make sure that they did fit with its plans for the Northeast are not entirely known. For example, SUDENE's own officials recognized that a better coordination between that agency and the National Department of Road (DNER) could have doubled the outcomes from the joint efforts (CEAS 1971 citing SUDENE 1968). Serebrenick (1963) asserted that integration and cooperation were not common characteristics among agencies working on the valley, even when dealing with the same problem. As examples, by 1963, CVSF and DNOCS, and CVSF and SUDENE had not implemented any project together (Serebrenick 1963). Nonetheless, Katzman (1977) acknowledged that SUDENE was very efficient implementing its own projects, especially engineering ones, through state and federal agencies or private corporations.

Summary of Chapter and Transition to Next Chapter

Drought and human responses to the phenomena, industrialization and urbanization elsewhere, and several governmental entities have influenced the use of water and the landscape of the basin. For example, DNOCS has been important in drought related infrastructure. The agency altered its focus employing water reservoirs and other resources of the Northeast for developmental purpose. One cannot deny the influence of CVSF in multiple areas and CODEVASF in matters of irrigation. SUDENE played a role in the irrigated agriculture in the valley with the development of irrigated pilot projects and increasing the demand for hydropower especially outside of the valley for industrial development and urbanization. The BNB supported several endeavors in the valley and in the Northeast providing loans.

The new form of water resources governance differs from old ones. It has become more integrated (e.g., institutions) and decentralized (e.g., shared tasks). The

new model of management created, distributed, and redistributed tasks. For example, the National Water Agency issues permits for water use, but it requires a license from the National Environmental Institute if the project can cause any harm to the environment. The old institutions are still part of the new system, together with their values and institutional memory, such as DNOCS as representative of the *hydraulic* approach.

Under the new policy, water is a public resource. Governmental agencies assign the right to use water but not ownership of it. The policies have not addressed the existing ecological problems and environmental services impairments of the basin. But it has the institutional capability of doing so, if it really distributes power and tasks among its institutions and does not hold it at the federal executive level. Environmental protection also needs to become priority in the management of the river's water. The system needs to develop ways to enforce policy; the focus has been on the implementation of the policy's instruments (e.g., payment for water use, new institutions). The model still needs to find solutions to major problems, water pollution and lack of natural flood. It can use the dams to recreate the natural regime of the river. The revitalization scheme is investing in sanitation programs, but the raw sewage still reaches the river, in addition to run-off from agricultural fields.

The next chapter describes the role that public engagement has had in the management of the *São Francisco* River. It describes how public initiated and mandated opportunities influence management of the river.

CHAPTER V

THE ROLE OF PUBLIC PARTICIPATION

This chapter addresses the following research question: **how does the new approach to water resources governance, endorsed by the Water Policy # 9,433 of 1997, promoted in the *São Francisco* River Basin by its respective watershed-based management committee, the *São Francisco River Basin Committee – CBHSF*, differ from old forms of governance regarding public participation?** This main division provides insights on the progress of public participation in the valley. Its evaluation is objective of Chapter VII. This chapter is based upon literature review, field observations and interviews made to assess the role that public participation has been playing in the management of the *São Francisco* River Basin.

The history of the *Northeast* (NE) of Brazil reveals several examples of citizen initiated participation or revolutions. The triggers for such public input are diverse. This chapter begins by illustrating popular forms of engagements with examples from the distant past. It then moves into more river related issues in an earlier period, and ends by shifting into contemporary ways of more direct water associated participation. This chapter shows the evolution in the diverse forms of participation, for example from citizen initiated also to include legally mandated.

The inter-basin water transfer project, the *Transposição* is "the case." It has attracted most attention and analysis regarding public participation. But this chapter also argues how mobilizations around dams have elevated the discussion over the issue of governance of river systems and its social and environmental consequences.

Public Participation or Popular Revolution?

The literature on the Northeast discusses unique examples of public engagement. People have resisted projects of social engineering and outside imposition (e.g., norms). A history of contest exists across the region going for example from *Antônio Conselheiro* in the 1890s to Dom *Luíz Flávio Cappio*'s hunger strike in the present century. Individuals have reacted against perceived unfair governmental practices and the lack of assistance for the poor.[1] Others have fought in favor of their own interests and protection as well. In addition, some might even argue that a number of those episodes were not a valid form of engagement because the leaders of such uprisings have been seen as both heroes and bandits taking justice in their own hands. *Antônio Conselheiro, Padre Cicero, Virgulino Ferreira, Dom Helder Câmara* and *Francisco Julião* are classical illustrations of public/citizen leadership intended to affect or just react against public policy or existing authorities.

The threat to the local identity and livelihood drove some to strongly defend their own beliefs and livelihood by, for example, moving into a new settlement opened to all (Beyer 1968). Various conflicting views labeled the leader *Antônio Conselheiro* as "charismatic", "megalomaniac", "messiah", and "political" figure (Madden 1991). *Conselheiro* was engaged with social aspects too. He maintained a scheme of communal production. His power of attracting workers in poor areas was viewed positively by farmers and colonels who needed labor (McCann 2009). From 1893 to 1897, he headed *Belo Monte*, a fully functioning community which included schools, warehouses, and even a small jail. *Canudos*, the name outsiders gave to the place, was located at the *Vaza Barris* watershed outside of the SFRB, in both *Bahia* and *Sergipe* about 160 kms southeast of *Juazeiro* (Chilcote 1990, Levine 1992, Cunha 2005, Johnson 2005). Indeed, *Juazeiro* was the site of the beginning of the dispute because a new

[1] The participation of *Luíz Flávio Cappio* will be discussed latter.

judge of that municipality cancelled *Conselheiro*'s shipment of wood to build a church in *Canudos*. The community lived from the contribution of its members, agriculture, and leather export (Madden 1991). State and federal governments did not support such an endeavor of a "state within a state" (Levine 1992) or the attempt of returning to a "monarchy" (McCann 2009); neither did urban elites (Borges 1993). According to McCann (2009), it was a harmless religious community instead of a national threat. In 1897, after several attempts, the Brazilian army destroyed the place (Levine 1992). Days before the end of the massacre, *Conselheiro* died of dysentery (Cunha 2005).

Cicero Romão Batista, a Catholic priest, born in *Crato, Ceará*, engaged in politics (Beyer 1968, Sanchis 2007). From 1872 to 1934, in *Juazeiro do Norte, Ceará*, he led religious and political crusades against the governmental system and in favor of the poor. Besides being a priest, *Padre Cicero* was mayor, federal representative and vice-governor. He became the most popular religious figure of the region, a saint in believers' views (Talento 2010, Della Cava 1968). However, the Catholic Church never canonized him.

Padre Cicero or *Batista* was controversial. His actions, such as the recognition of what he and his followers, including priests, alleged to be a miracle, did not make everyone happy, including the hierarchy of his church (Della Cava 1968, Sanchis 2007). The Catholic Church expelled him in 1917 for breaking hierarchical rules. He even gave *Lampião*, another contested figure, the title of captain (Talento 2010). Due to the priest's popularity and for attracting crowds of about two million of pilgrims per year to *Ceará*, the church decided to review his case to possibly grant him rehabilitation (Sanchis 2007). The case is still under review.

From 1920s to 1938, *Virgulino Ferreira da Silva* or the *Lampião*, led his group of bandits in the Northeast. They took justice into their own hands, which included robbery, assaults and murders. *Lampião* fought against the injustices he had lived through his

youth, highlighted by the death of his father in which a police chief participated (Pierson 1972, vol.1).

From the 1930s to retirement in 1985, *Dom Helder Câmara*, the archbishop of *Recife-Olinda*, worked to improve the life conditions of the poor, people and nations, and was the image of the Liberationist Catholicism. He reached a broad range of supporters from students to politicians, religious and lay individuals, and had enemies as well namely the officers of the military regime (Serbin 1999). He confronted social, economic and spiritual issues (Camara 1971).

Beginning in the 1950s, the Catholic Church's religious leaders engaged in a more participatory approach seeking solutions to the socio-economic problems of the Northeast, such as the agrarian ones. For example, the National Conference of Brazilian Bishops – CNBB, which existed since 1952, had *Dom Helder* as its general secretary for over a decade (Serbin 1999). Leading church figures got involved with the rural workers associations' movement and created and implemented assistance programs (Souza 1979). Members of the church created ecclesiastical base communities, and later on pastoral commissions, such as the Pastoral Land Commission – CPT, which has been an important group in the citizen initiated fight against dams and the inter-basin water transfer project.

Catholic religious leaders tried to do what the government was not doing for the Northeast. They had an effect on policy and politics. They brought attention to the problems of the region, held meetings with members of governmental entities, and were influential in the creation of the Development Superintendence of the Northeast – SUDENE (Furtado 1989, Souza 1979). President *Juscelino Kubitschek* invited *Dom Helder Câmara* and representatives of various interest groups to a brainstorm section in *Petrópolis* in January of 1959. *Dom Helder* did not attend that meeting but he and the president met in a conference of Northeasterners bishops held in *Natal* in May of that

same year (Furtado 1989). The Catholic Church has actively supported peasant-workers in their fight for land and a better livelihood in the valley, such as in the lower-SFR (Lopes 2007).

On the socio-political front, a deputy and lawyer, *Francisco Julião* inspired peasant leagues, *Ligas Camponesas*, in *Pernambuco* and in other states of the region. His movement was even able to concern United States President John Kennedy in the early 1960s (Chilcote 1990). At that time, *Julião* was seen by some as a personified "communist threat" that could lead Brazil into a Cuban-style revolution.

Forman (1971) noted that political radicalization of the peasantry in rural Brazil resulted from urbanization, industrialization, and transformation of agriculture into a capitalized sector. The characteristics of more recent mobilization regarding the *São Francisco* River Basin fit with those mentioned above and with the economic approaches implemented by the federal government. These development programs introduced new uses and users to the valley and led to many environmental and social consequences. Local residents did not have any input in the decision making process, but needed to shoulder the sacrifices of implementation and post-construction phases. In the past, citizen-initiated movements such as the ones mentioned above had a broader focus and show a history of contest. Water issues were not voiced in isolation. The access to *São Francisco*'s water and river resources had been one among various demands. But that has now changed as this chapter will show.

Limited Possibilities of Participation

This section describes political and socio-economic variables that have inhibited public participation in the *São Francisco* River valley.

Latifundium, Colonelism and Clientelism

Colonels (*coronéis*) were influential figures who held power at the local level due to their socio-political and economic status on the community. They usually had political connections, owned vast herds and possessed large estates (*latifúndio*). Up until the 1930s, the nation's power and economy were closely tied to land. Colonels were members and leaders of the Brazilian National Guard during the *Old Republic* (1889-1930) (Chilcote 1990). Locally and regionally, they used guns to enforce their law.

From 1930 to 1945, Brazil had a strong populist and nationalist head of state who used a civil ruling approach to govern the country from 1937 to 1945. "The Revolution emphasized decision making at the national level rather than the state or municipal levels" (Chilcote 1990, 71). President Vargas chose interveners to represent each state and to reduce the power and influence of *colonels*. Various regions started to receive more national capital and development was triggered by federal governmental policy. Examples include the anti-drought policy in the 1934 Constitution and during the late 1940s and 50s pro-development programs based upon hydropower projects for the valley.

The new approach did not eliminate *colonelism*. After WWII, elections or appointments also depended on the power exerted by members of local economic groups and of other interests (Chilcote 1990). The new figures, the interveners were still a form of centralized representation, but with power not necessarily linked to land (e.g., political influence of the capital). The political clout of state capitals had risen. In many parts of the Northeast of Brazil, such as in *Juazeiro* and *Petrolina*, powerful groups benefited from the maintenance of the status quo. For example, during extreme weather events such as droughts, governments increased the level of resources for the ones inhabiting the semi-arid region. As stated by Chilcote (1990, 154-155) in the assertion below,

> Throughout the long history of government projects to combat drought, the ruling classes were able to channel state and federal funds for the construction of roads, reservoirs, dams, and irrigation systems to their ranches. This favoritism served to isolate a large part of the backlands population. Compounding the problem, these privileged landowners also built fences around their property to restrict access to water and grazing lands.

In addition, to the fact described above, the so-called "drought industry," a sense of paternalistic and feudal perspective guided the relationship among the ones in governmental entities and the general population (Pierson 1972, vol. 3). This culture persists, especially in the countryside of the Northeast, even in the absence of an older form of *colonel* and in a democratic nation. Now the political chief is not only centered on the figure of the traditional *colonel*. This person has a new face and position in the decision-making process. Votes for modern 'colonels' or their political candidates are exchanged for jobs, participation in social programs, shoes, food supplies, protection and other favors such as benefits with the justice and public services. Similar to the past, resources which include ones of a public nature have also been distributed to people on political criteria (*clientalism*). The colonel-client relationship has for long time meant the exchange of the client's vote for favors or in some cases only promises. Since the client receives the instruction regarding for whom to vote from the modern-day colonel, this system has historically undermined the real participation of the client, usually a rural peasant, in the election process. More in the past than today, the peasant "...was insulated from the pressure of the outside world by the attitude of *noblesse oblige* of the plantation master" (Forman 1971:5).

Unfortunately, the power of the modern colonels still exists even when they have already passed away. A May 2010 newspaper article, in *Salvador da Bahia*, reported on how "power, tradition and entrepreneurship" still elect sons and grandsons of political

figures. Their electoral power is based upon what family members used in the past (A Tarde, 01 May 2010).

Twenty-One Years of Military Dictatorship

The 1964-1985 military dictatorship limited existing forms of public participation from elections to associations. Elections for presidents from 1966-1985 and for governors from 1966-1978 were indirect. The government constrained, suppressed and even dictated how conflicts should be handled (Forman 1971, Favareto 2006, Chilcote 1990). But, even during this delicate time, public engagement existed in the countryside, such as in the form of rural labor unions seeking agrarian reform and protection of laborers' rights; and fighting against both the dictatorial state and land concentration (Favareto 2006). The government reacted, repressed associations and peasant leagues such as the ones inspired by *Julião*, with the arrest and exile of its members (Forman 1971).

The government regulated other labor associations too. Fishermen's associations were connected to, managed, and controlled by the Brazilian Navy. An example of such repression took place in a city of the lower- SFR. A group of fishermen received the title of "subversive" because they created their own independent association. The army brought the group of fishermen to the state capital for "questioning" (Fishermen-CBHSF, PC, 17 Jan 2007, Penedo-AL).[2] Illustrations of military rule were present in other aspects of the Northeastern society. In *Petrolina* and *Juazeiro*, the military investigated local government's members and got involved in local affairs including public ceremonies (Chilcote 1990).

The government impaired but was unable to inhibit all forms of public participation. As an interviewee, a religious figure said, he ended up transferred to a

[2] PC means Personal Communication.
Besides fishermen other river related workers' groups existed in the valley. For example, in the 1940s, river steamer workers created an association. In the following decade they were linked to unions. In 1960, steamboat workers undertook a 108 days strike (Neves 1998).

riparian city in the basin due to his anti-dictatorship beliefs (Religious figure, PC, 05 Jun 2007, Brejo Grande-SE). He was deemed not to fit in the place where he had been previously assigned due to his revolutionary ideas. His work of engagement did not stop.

During the period of military rule, the nation took the first steps towards democracy and public participation. In 1965, the Law# 4,717 – Law of Public Action sought to eliminate the causes of environmental damage. In 1979, the Law# 6,767 brought to an end the two existing political parties and allowed the creation of multiple parties [Law#6,767 of 1979]. In 1980, a constitutional amendment mandated direct election for governors and senators [Constitutional Amendment# 15 of 1980]. Regarding the environment, the Law# 7, 347 of 1985 regulated public civil actions which could be brought against those damaging or acts that could damage Nature. The 1988 Constitution inaugurated a new phase as mentioned in Chapter IV. Water Resources Governance. The constitution mandated the independence of labor unions and associations [Art. 8]. It also created possibilities for public engagement and for participation in the decision-making process (e.g., councils). The first direct election for president after twenty-one years of military ruling took place in 1989.

Public Reaction as a Form of Engagement and Participation in River Related Issues

In the late 1970s, the construction of large hydropower infrastructure and its consequences, namely land reappropriations, instigated a new form of citizen initiated participation in the region, the reaction of those affected by the future dam. An important characteristic of mobilizations in the NE was that local populations have also relied upon the presence and guidance of strong religious leaders. Heads of churches have triggered public reactions, moving beyond the general lack of participation and the 'choice' for political representativeness. CEAS (1971) and Goulet (2005) described the importance of the pressure exerted by religious figures, local citizens, non-

governmental organizations and to a certain degree politicians, in the mitigation of social problems related to the SFR, such as resettlement of populations due to the construction of hydropower infrastructures. Goulet (2005) also acknowledged that the engagement of those groups of stakeholders over decades was even vital to the creation of the newly mandated participatory approach of management for river systems in Brazil. The ones affected by dams were able to project their voices beyond local boundaries, sending the message to and throughout international nongovernmental organizations and international inter-governmental institutions. But, it has been a long journey for the water to be seen not only as part of the land.

Against the Dams

In the 1970s, the movement of people affected by dams introduced a new model of participation in the valley moving the attention away from labor classes and land issues and towards the river too. Public engagement in the basin then took place as a form of reaction against the construction of the future hydropower infrastructures and all the social consequences it could create.

In the case of *Sobradinho*, the building of the reservoir led to a forced resettlement of people and towns, loss of fertile land in the inundated riparian zones, and change in river regime in the lower-SFR (Hall 1994). Public participation was initially unorganized. It later included institutionalized groups such as "associations, cooperatives, and unions" (Favero and Santos 2002:122). The Pastoral Land Commission of the Catholic Church played an active role in public engagement (Goulet 2005). But, it had a small impact in decision-making in comparison with what would take place in the case of the other dam, *Itaparica*. Besides, land was still the major issue of concern and object of conflict.

In the protest against the construction of *Itaparica* Dam, public reactions passed through various stages. The government planned the dam in mid-1970s and started building it in 1980. Public participation took place at an earlier phase than in the case of Sobradinho (Hall 1994). Indeed, members of social movements had learned about the environmental and social damages such projects could cause from that close by experience; besides the way the officials had handled *Sobradinho* had made the matter even worse. According to Bartolome (1999), Sobradinho encouraged stronger and more structured future movements in the valley. "In earlier projects, residents were not informed of flooding schedules and had no voice in negotiating levels of monetary compensation, relocation sites, or terms of economic reactivation" (Goulet 2005, 893). The local residents did not want to let this re-occur. In addition, a fading military dictatorship was not seen as a threat to mobilization as before (Hall 1994).

Before the beginning of the anti-dam mobilization movement for *Itaparica*, the Catholic Church's leaders had already brought the population's attention to the fact that another dam besides *Sobradinho* would be built in the region and that affected people needed to organize themselves (Bartolome 1999). In the first phase of the movement against *Itaparica* Dam, local residents reacted in opposition to the way the representatives of governmental entities had claimed proprieties for the construction of dams in the valley based upon force and violence (Araújo 1992).

The presence of more members of the Catholic Church, rural workers associations and other non-governmental entities, and consequently the existence of a more organized movement characterized the second phase of the reaction against *Itaparica*. As in the case of *Sobradinho*, the search for land motivated the group. The *Polo Sindical*, a rural trade union was the leading entity, with the support of community organizations, the Catholic Church, and international NGOs (e.g., Oxfam) which brought local's voices into the public eye. They also revealed the World Bank's participation in the project (Hall

1994, Goulet 2005). The structured movement was able to organize street demonstrations, halt building vehicles, occupy working sites, stop construction, and then negotiate conditionality for the resettlement with the *São Francisco* River Hydropower Company – CHESF. Members of the group also reacted when the promises and accords were not met (Bartolome 1999, Araújo 1992, Goulet 2005). The accord between CHESF and the local population had included the provision of information such as maps and plans, housing, land with irrigation systems and a stipend until future harvests (Hall 1994, Bartolome 1999, Goulet 2005). The accord forced a change in CHESF's plans. It replaced CHESF's initial intentions of building new cities for urban residents only, with no plans for rural ones (Hall 1994, Goulet 2005).

Nonetheless, the outcomes of the resettlement were not entirely positive (Araújo 1992). Not all displaced residents received compensation, the social and economic conditions of those the government resettled often deteriorated. It took years for many to receive irrigation equipment to be able to farm the new lands. Anger, violence, and alcoholism increased in the community (Horgan 1999). In addition, not all those resettled adapted to the modern agricultural model CHESF introduced. Despite the failings in terms of social and environmental outcomes, at least one positive issue needs to be pointed out as regards public participation. A nongovernmental popular organization in effect influenced decision-making regarding the design of a resettlement project (Goulet 2005).

Fish Mortality in the Lower-middle *São Francisco*

Citizen initiated participation in the valley also took place as a form of reaction against environmental problems that just had taken place: water pollution and fish mortality. In 1984, for example, 35,000 m^3 of a by-product of sugar-cane processing with a high content of organic matter, spilled from an agribusiness corporation, the *Agrovale,*

into a *São Francisco* River's tributary, *Riacho Tourão* (Simões and Moura 1984).[3] The contamination caused overnight fish mortality by asphyxiation of about 400 tons of fish from *Juazeiro* to *Curaça* about a hundred kms of river stretch (Simões and Moura 1984; Chilcote 1990; NGO representative, PC, 03 Aug 2006, Juazeiro-BA).[4] The municipality of *Curaça* shut down the public water supply system due to the amount of dead fish. The problem also impaired the subsistence fishery and caused human exposure to pathogens (Simões and Moura 1984).

A Catholic Church Bishop, *Dom José* led a demonstration of five thousand people (Chilcote 1990). This event triggered citizen engagement under the name of Movement in the Defense of the *São Francisco* (*Movimento em Defesa do São Francisco*) in *Juazeiro* and *Petrolina* (head of NGO, PC, 03 Aug 2006, Juazeiro-BA, NGO representative, PC, 03 Aug 2006, Juazeiro-BA). Other entities got involved to investigate the fish mortality, such as an environmental NGO from *Salvador* – GAMBÁ, a university professors' association – APUB, and the *Bahia* State Environmental Agency – CRA (Simões and Moura 1984).

The *Movimento em Defesa* went beyond its initial scope. The low level of water in *Sobradinho* reservoir and deforestation in the region also concerned its members. These ranged from mothers' associations to political parties. They pressured governmental institutions into taking more actions to protect the river. The group organized, among others, public demonstrations, carnival parties and church masses in *Petrolina* and *Juazeiro*. It promoted environmental education with seminars and conferences, presentations in schools, theater plays and radio programs. As a consequence, the *Bahia* environmental agency created a branch in the region (*Centro de Recursos Ambientais* -

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[3] The *Agro-Indústrias do Vale do São Francisco* S.A. – *Agrovale* is a private agricultural company created in 1972. It is located at and works in the *Sertão* of *Bahia*, in Juazeiro, lower-middle-SFR, producing sugar and ethanol from irrigated sugar-cane. It is one of the biggest sugar producers in the Northeast (Agrovale 2007).

[4] Asphyxiation caused by the reduced content of oxygen microbial populations used to break down the high content of organic matter.

CRA). The polluter was found guilty and paid a fine for having caused the problem (Simões and Moura 1984). But, the *Movimento* then ended and it never became an official NGO. Some members have created a new group in recent years. When questioned about the outcome of the initiative, a member of the movement said that today more control over the visible causes of environmental problems exist, but these still occur in more hidden ways in the area (NGO representative, PC, 03 Aug 2006, Juazeiro-BA).

Religious Activities

In different parts of the watershed, the local residents participated and discussed social and environmental issues also as part of religious events (Clothes washer 1, PC, 15 May 2007, Pirapora-MG; Retired boat worker, PC, 04 Jun 2007, Brejão-Brejo Grande-SE). Catholic priests and bishops have mobilized the population and attempted to influence politicians (Chilcote 1990). For example, Bishop *José Rodrigues* engaged people in *Juazeiro* in *Bahia*. He demanded that politicians work for the poor and against the effects of droughts. He called for public participation (Chilcote 1990). *Dom Luiz Cappio has* engaged residents in various states of the basin (Researcher, PC, 24 May 2007, Belo Horizonte-MG). He undertook a river long pilgrimage in 1992-93. His objective was to bring awareness about the river and the people who depend on it. He has seen an increase in public engagement along the river entire extension. He observed change, in a positive ways, in how people are speaking about and using the river since then. But many problems still exist, as many governmental bodies have not changed their behavior, including in the case of the *Transposição* project. In the last thirty years, in general, people's consciousness of the river's situation "changed: it grew, increased in volume, and became deeper" (Cappio *et al.* 1995; Religious figure, PC, 13 Jan 2007, *Barra*-BA).

The Catholic Church was active in the lower-SFR too. According to a religious figure, the church's presence is strong. "No place in the lower-São Francisco exists where you cannot see the actions of the church". A growing level of public commitment is evident. The local residents are now engaged against the construction of a new dam in the lower-SFR, the *Pão-de-Açucar* (NGO representative, PC, 05 Jun 2007, Brejo Grande-SE).

Other Organizations

Local NGOs have worked on public education, reaching communities even by boats (Fishermen and NGO member, PC, 19 Jan 2007, Penedo-AL). In the low-SFR for example, the level of public participation is higher today than it used to be in the past (Head of fishermen association, PC, 17 Jan 2007, Penedo-AL). In *Minas Gerais*, the increased level of public awareness has been noticed too. Pirapora's local newspapers report upon many environmental problems. Society there has demanded change (Researcher, PC, 24 May 2007, Belo Horizonte-MG).

In the 1990s, a movement named *SOS São Francisco* brought attention to the river and basin. It led to the creation of a civil society entity, *Instituto Manoel Novaes* – IMAN, which elected its first board of directors in 1996 (IMAN 2007, CBHSF 2007). IMAN works on multi-disciplinary aspects of the SFR's basin, such as historical, economic, social, cultural and environmental. It seeks to educate local residents on their own history, strengthen institutions, and to increase the level of environmental protection (IMAN 2007). In 2001, it was in charge of the mobilization for the creation of the São Francisco River Basin Committee – CBHSF that the 1997 Water Policy mandated (CEEIVASF 1997).

In 1997, the Medical School of the Federal University of *Minas Gerais* created the *Projeto Manuelzão*. This is a civil society organization whose initial efforts were to link the students sent on internships in the countryside of the state with the communities they

visited. University professors headed up the organization. An important aspect of the project was the recognition that many health problems result from the quality of the water. The engagement in the *Projeto Manuelzão* increased the activities of the *Rio das Velhas* Watershed-based committee (NGO-CBHSF, PC, 24 May 2007, Belo Horizonte-MG). The committee had existed since 1997 as a result of a World Bank's conditionality for a loan. But the committee only gained visibility due to *Projeto Manuelzão*'s ties to it in 2003 (Abers and Keck 2009).

Mandated Participation

This section introduces the contemporary phase of mandated public participation in water resources management of the *São Francisco* River. It explains the genesis, describes the institutional arrangement and organizational details of the SFR committee. It helps us to understand how participation can and takes place at the lowest institutional level of the newly created Brazilian water governance system, the river basin committees.

The *São Francisco* River Basin Committee – CBHSF

In March 29, 1978, the Interior and the Minas and Energy ministries jointly created the Special Committee for Integrated Studies of Watersheds, the *Comitê Especial de Estudos Integrados de Bacias Hidrográficas* – CEEIBH [Inter-ministry Administrative Rule# 090 of 1978, CODEVASF 2001, MME *et al.* 1982]. The CEEIBH adopted the watershed as a unity of management and sought to identify the problems created in the light of water resources use and management (CEEIBH 1981, MME 1982). It was in charge of classification, investigation and assuring the rational use of national water bodies for multiple purposes minimizing the occurrence of ecological harm (MME 1982). The CEEIBH included the national environment secretary, representative of the national water and energy department, and states secretaries linked to water resources institutions (MME

1982). The committee worked until 1983, but was only legally eliminated by the approval of the 1997 Water Policy (CODEVASF 2001).

The CEEIBH and the other committees which resulted from it had a consulting role (Tucci *et al.* 2000). The committee for the *São Francisco*, the *Comitê Executivo de Estudos Integrados da Bacia Hidrográfica do Rio São Francisco* – CEEIVASF started to exist in October 1979 (CODEVASF 2001, CEEIBH 1984). Members of the *São Francisco* committee included the development agency for the Northeast and for the valley, the port national agency, and state planning, water and sanitation institutions (CEEIBH 1984). CEEIVASF and its working areas sub-committees, namely planning, territorial zoning and ecological preservation, sought to carry out integrated studies and to oversee water uses in the valley (MME 1982, CODEVASF 2001). Its outreach alternatives included links to inter-state parliamentary commissions, non-governmental organizations, local governments and users (CEEIVASF 1997, CODEVASF 2001). It provided institutional alternatives for non-mandated public participation and inter-agency collaboration. It was progress toward the committees that exist today. The CEEIVASF even proposed amendments to the law project which resulted in the 1997 Water Policy (CEEIVASF 1997).

The committees that we know now were mandated by the 1997 Water Policy. The National Water Resources Council – CNRH approved the formation of the São Francisco River Basin Committee – CBHSF in May 29, 2001. The President of Brazil created the CBHSF in June 05, 2001. The CBHSF is an independent institution directly linked to the National Water Council because the SFR is defined as a national river [CNRH Resolution# 5 of 2000, Art. 1, §2°]. Legally the CNRH can only interfere with the work of the committee if it does not meet the 1997 Water Policy's requirements and the CNRH Resolution# 5 that specifies committees' directives [CNRH Resolution# 5 of 2000, Art. 4]. The National Water Council is also a court of appeal which can refute CBHSF's decisions [CNRH Resolution# 5 of 2000, Art. 7].

CBHSF as any other watershed committee is in charge of: (1) conflict resolution on the matters of water resources of the basin; (2) approval of the watershed-based management plan; (3) deciding upon the proposals its watershed agency suggests; and (4) approval of the committee's bylaw [CNRH Resolution# 5 of 2000, Art. 7]. The CBHSF sets rules, decides on matters and also acts as a consulting entity.

The SFR watershed's natural boundaries delineate the zone under management of the CBHSF. The committee's members represent the union, states, the Federal District, and municipalities included in the basin; civil society groups and spokespersons of water users that deal with or influence water resources in the basin.

The Environmental Minister, president of the National Water Council, appointed the first board of directors of the CBHSF, a provisory one, in 2001. The group included nineteen members [CNRH Administrative Rule# 367 of 2001]. The board was in charge of among other things, creating the conditions for the implementation of the committee working for its first election to occur. The National Water Agency oversaw and the *Instituto Manoel Novaes* – IMAN undertook the task of contacting and informing people in the valley about this new opportunity of participation in the governance of the river. The National Water Agency also provided funds for the endeavor (CBSHF-consultant, PC, 07 Jul 2007, Salvador-BA). IMAN was able to involve about six thousand people (CBHSF 2007), a considerable accomplishment.

The first elected members to the SFRB committee, a total of sixty took office in December 2002.[5] The new members selected the first elected board of directors in *São Roque de Minas* in 2003 [CBHSF Plenary Minutes of 11 of May, 2003]. The first elected president was *José Carlos Carvalho*, from *Minas Gerais* Environment and Sustainable Development Secretary [CBHSF Plenary Minutes of 11 of May, 2003].

[5] Eleven members were not elected, they were appointed by governmental entities that have selected seats.

A vote by two-thirds of members can alter the CBHSF bylaws. CBHSF's statute establishes the number of representatives and how they should be chosen. The election process for the non-governmental members is public. Governmental entities have a selected number of seats. Municipalities are the only governmental level that selects its members through election.

Initially, peers elected CBHSF's members for a two-year term with re-election for the maximum of that same amount of time [CBHSF Bylaw of 2002, Art.46 and Art.47]. The period has been extended for three years with a maximum of three reelections [CBHSF Bylaw of 2007, Art.46]. CBHSF's members select a president, a vice president, and a secretary to direct the CBHSF for a three-year period. They also can be reelected for equal period [CBHSF bylaw of 2007, Art.8]. Two-thirds of the CBHSF's members, in an extraordinary meeting, can overthrow the members of the directory [CBHSF Bylaw of 2007, Art.8, §2°].

Members' participation in the CBHSF does not entitle them to any form of work payment [CBHSF Bylaw of 2007, Art.49]. It is voluntary for anyone whose job (e.g., governmental agency, private corporation, NGOs) will not pay for the time the staff spend dealing with committees' issue. Different segments of the society comprise the sixty-two-member committee (Figure 5.1 below). As already mentioned, sixty used to be the number of titular members. Representatives of governmental bodies occupied a total of twenty seats: The federal government took up five positions; the state of the basin and the Federal Districts each had one seat; and municipalities of Minas occupied three, Bahia had two, and Pernambuco, Alagoas and Sergipe one seat each. Representatives of water users' segments occupied a total of twenty-four seats and members of the civil society connected to water issues filled up sixteen slots [CBHSF Bylaw of 2002]. Indigenous people had one position for a representative under a civil society slot. In addition, a national agency in charge of indigenous rights protection – FUNAI is one of the Union's

members occupying a government's seat. A new version of the bylaws passed in 2007 added two new seats. Indigenous people representatives hold these two positions besides the already existing FUNAI position. A representative of slave descendant's communities now occupies a position for the traditional community under civil society [CBHSF Bylaw of 2007]. Cases exist where a member of one category can also belong to another one. For example, a governmental corporation might also be a user. This fact increases the real number of governmental members in the committee.

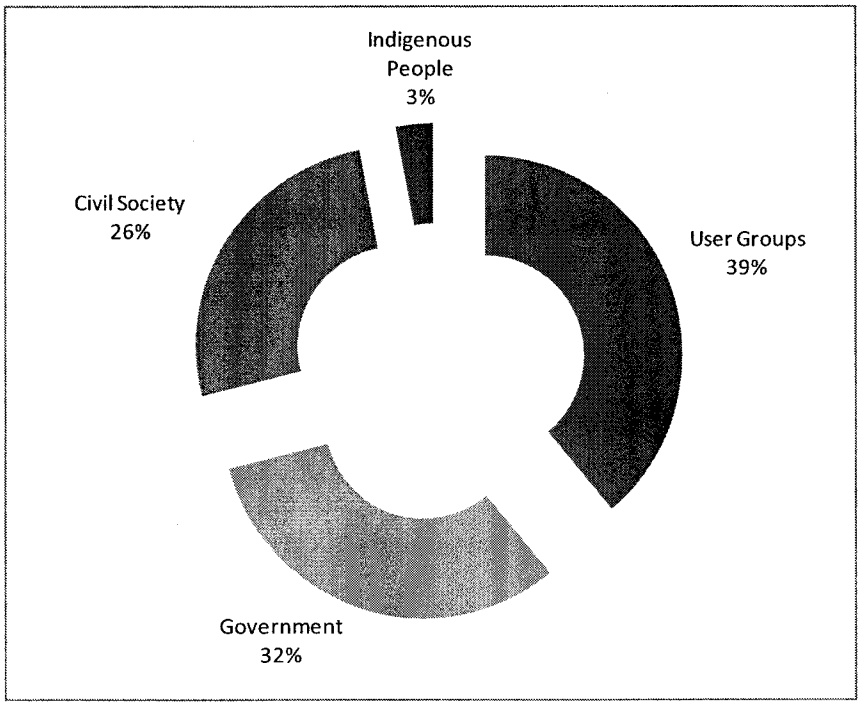

Figure 5.1. The Sixty-Two Member CBHSF Committee

An executive and a collegiate board of directors, an executive-secretary to be replaced by the water agency or delegate agency for the watershed, plenary, technical chambers, and regional consulting chambers compose the CBHSF [CBHSF Bylaw of 2007].[6] The SFR water agency is the entity that is supposed to be the executive-

[6] The president, vice-president and the executive secretary form the executive board of directors. This board together with the four coordinators for the regional consulting chamber forms the collegiate directory.

secretary of the CBHSF. The process of selection of its delegate agency has ended. The CBHSF chose the *Associação Executiva de Apoio à Gestão de Bacias Hidrográficas Peixe Vivo* from *Minas Gerais* – AGB – Peixe Vivo. This is an entity with juridical personality, different from the CBHSF which only promotes management, but cannot execute or enforce policy as respectively the watershed agency and federal or state water and environmental agencies do. *Peixe Vivo* will be the implementing body.

The sixty-two members of the SFRB committee present proposals and suggest issue to CBHSF's secretary for discussion by the plenary [CBHSF Bylaw of 2007, Art.39]. The secretary proposes to the president the inclusion of the issue in the CBHSF's agenda of the committee based upon chronological order [CBHSF Bylaw of 2007, Art.25]. The matter can also be debated by technical chambers. An issue is included in the agenda of a following meeting if it receives the support of one-third of CBHSF's members.

The plenary meets twice a year with the gathering announced thirty days prior to taking place. Special sections can be held under presidential request or demanded by one-third of the CBHSF's members and announced fifteen days before the meeting. Plenary meetings are open to the public and advertised [CBHSF Bylaw of 2007, Art.13 to 16]. The plenary decides where the gathering will take place [CBHSF Bylaw of 2007, Art. 18].

Decisions take place by consensus or by two-thirds of the members present. The vote is open. Members are not forced to vote as Brazilians are in elections, and the president of the meeting only votes in case of a tie [CBHSF Bylaw of 2007, Art. 23]. CBHSF's members also decide upon the creation of technical chambers. They are made up of from seven to thirteen members appointed by CBHSF's titular constituents [CBHSF Bylaw of 2007, Art. 32]. Those entities undertake investigations and decide upon technical matter, bringing their decision to plenary attention. Technical committees can invite specialists to provide information too. Regional consulting chambers are the links

among the CBHSF and sub-basins' committees. Besides CBHSF's members it also can include members of watershed-based committees of SFR's tributaries [CBHSF Bylaw of 2007, Art. 35]. The consulting groups and the CBHSF promote the interactions among sub-basins and the CBHSF, share information on river related issues with the committee and the sub-basin region, and point out issues of concerns promoting alternatives to address them. Regional groups hold CBHSF's public meetings with the society in general, mobilizing locals for the election process [CBHSF Bylaw of 2007, Art. 27]. The CBHSF has five technical chambers: Institutional and Legal – CTIL; Grant and Payment – CTOC; Institutional Articulation – CTAI; Traditional Communities – CTCT; and Plans, Programs and Projects – CTPPP. The committee has four regional chambers: upper, middle, lower-middle and lower-SFR. The Figure 5.2 below represents the structure of the *São Francisco* River Basin Committee.

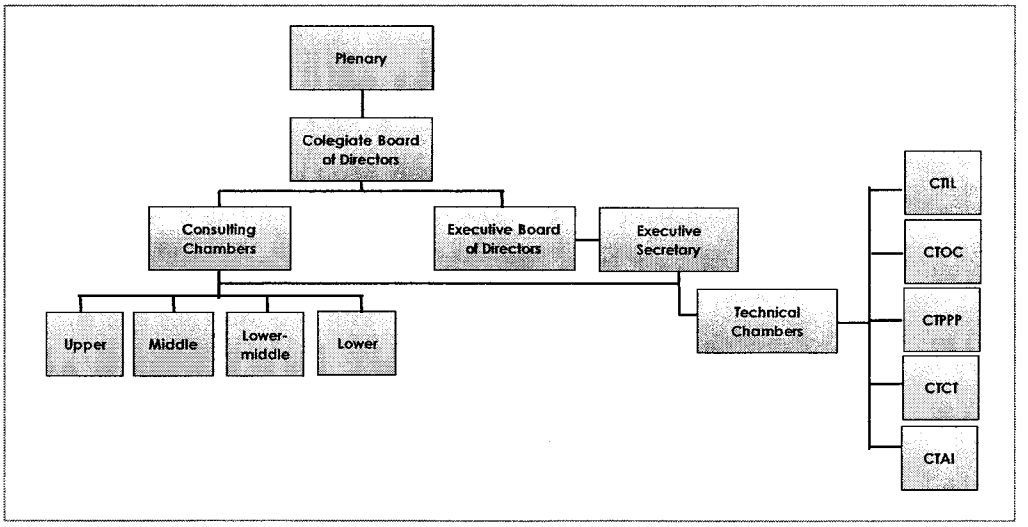

Figure 5.2. The Structure of the CBHSF
Source: Redrawn from structure presented at CBHSF (2007, 45)

The committee seeks a holistic approach to management for the basin. Its responsibilities range from decision-making, such as the approval of the plan for the basin, to resolution of water use conflicts at first level of the decision-making process. The National Water Resources Council is in charge of resolving conflicts not solved at the

committee's level. The committee is also in charge of increasing debate on issues related to the basin, and of monitoring the implementation of policies and of the plan for the watershed. The CBHSF proposes to the National Water Council the volume not to be charged for use because they are considered as of low expression for effluent discharge, and water withdrawal, transference and accumulation. The committee should implement the methods for the water payment system and suggest the amount clients will pay for the use of the water resources of the valley in agreement with state's water policy. It is also in charge of promoting the creation of the watershed water agency or delegator agency [CBHSF bylaw of 2007, Art. 5].

The CBHSF has eleven sub-basin committees. One of them is for an inter-basin tributary, the *Rio Verde Grande*, and the other ten are state river committees (ANA 2009b). *Minas Gerais* has the highest number of sub-basin committees.

The 2007-2010 Election Process. Prior to this one, two electoral processes had taken place (2002-2005 and 2005-2007). The procedures for the fourth election started in the first day of January 2010 and it will end in Aug 09 and 10 of this same year. The third electoral process selected CBHSF's members for the 2007-10 timeframe. This section focuses upon the 2007-2010 process to illustrate the course of actions.

One of the first steps of an electoral process is the definition of its agenda. The CBHSF advertises the time frame and procedures of enrolment throughout various media sources, such as commercial and official newspapers (e.g., Tribuna da Bahia, 17 May 2007; Diário Oficial da União, 02 April 2007c) and internet sites (Figure 5.3 below).

Agencies, organizations of the states involved in the CBHSF publicize the process too, such as the Bahia Agriculture Development Company – EBDA. The CBHSF and the National Water Agency hold meetings to explain the importance of the committee, the election process and how to participate on those.

The committee accepts the enrollment form and the required official documentation of the possible candidates, which includes papers that show that the candidate is an organized group (e.g., organization), or a private institution that represents one. Governmental agencies such as water agencies receive the documentation to provide legitimacy to the process. Recipient places are located at the different members' states and in the Federal District. The documentation can be handed in person or delivered by mail (Tribuna da Bahia, 17 May 2007).

AGÊNCIA NACIONAL DE ÁGUAS
COMITÊ DA BACIA HIDROGRAFICA DO RIO SÃO FRANCISCO

EDITAL DE CONVOCAÇÃO Nº 1, DE 13 DE MARÇO DE 2007

Pelo presente Edital, a Diretoria do Comitê da Bacia Hidrográfica do Rio São Francisco - CBHSF, no uso das atribuições que lhe foram conferidas no seu Regimento Interno, e obedecendo a Resolução Nº 05, de 01 de março de 2007, que estabelece normas, procedimentos e critérios para o processo de renovação dos membros titulares e suplentes do CBHSF - Gestão 2007-2009, CONVOCA os representantes dos seguimentos Usuários da Água e Organizações da Sociedade Civil para se inscreverem visando à habilitação para participarem das Plenárias de Eleição dos novos membros titulares e suplentes do CBHSF, conforme cronograma apresentado a seguir:

CRONOGRAMA DE ELEIÇÃO DOS NOVOS MEMBROS DO CBHSF	
ETAPAS	PERÍODO
Período de Inscrição	De 18/04/07 a 18/05/07
Divulgação da lista dos habilitados (preliminar)	31/05/07
Prazo para impugnação	De 01 a 05/06/07
Prazo para recurso	De 06 a 11/06/07
Publicação da lista de habilitados (final)	18/06/07
Plenárias Eleitorais Setoriais, Indígena e de Prefeitos	De 02/07/07 a 14/07/07
Plenária de posse dos membros e eleição da Diretoria	09 a 10/08/07

Figure 5.3. Election Ad
Source: Diario Oficial da União 02 April 2007, Section 3, 101.

The Institutional Articulation chamber was the electoral committee. It checks the submissions and publishes a list of the eligible candidates. Applications deemed unfit have the chance of appealing and/or submitting missing information. At the end of the review process, the committee publishes the final list of the nominees. In the case of the 2007-2010 election, 873 applied but only 373 were suitable for a position in the election plenary (CBHSF n.d.c.). The first election (in 2002) had 1,351 eligible candidates (Garjuli n.d.).[7]

In the third election, the candidates chose their representative eligible peers in meetings that took place from 02 to 14 of July 2007. Some of those meetings can take from one to two days depending on the number of groups or individuals to be chosen. On July 9, 2007, in an afternoon meeting in *Salvador*, city mayors eligible to vote selected the representatives of local government groups to occupy the four slots, two for titular and two proxies for the municipalities in the basin under the jurisdiction of the state of *Bahia*. Four eligible representatives were present. They selected, among themselves, two members and two proxies. The CBHSF presented the sixty-two elected members in the XV and XVI Plenary, in *Piranhas* (AL), in August 2007. They then chose a *Minas Gerais* NGO member, *Dr. Antônio Thomaz Gonzaga da Mata Machado* to the presidency. They also elected the vice president, the executive secretary, and the head of the chambers. The presidents of the CBHSF have predominantly been from *Minas Gerais*.

Public Information. The internet is an important tool for the committee. The CBHSF posts invitations and the agenda of the plenary. It also publicizes information regarding the election processes, news about the river, issues of concern, and research reports. E-mail facilitates contact between members of both, CBHSF and of working groups (chambers). Still official invitations such as to the plenary are sent by normal postal mail. The committee employs other ways of communication too, such as newspapers,

[7] The first elected members took office in 2002 for the period of 2003-2005.

circulating cars with sound boxes, and flyers. Local residents interviewed in the municipalities visited mentioned having heard what they think was an advertisement of a committee meeting through such sound cars.

Legally Required Public Participation. In theory, the CBHSF follows the Brazilian representative model. The input from citizen is incorporated via this process. During a workshop and two plenary that I attended, in *Minas Gerais*, I did not witness the engagement of average citizens. Everyone there was linked to the CBHSF as: a member, as a member of educational institution, or were participants from governmental agencies. I did not see average citizens present at the two regional meetings which I attended in *Aracaju* and *Petrolina*, nor in the two chamber gatherings and electoral meeting in *Salvador*.

The Space for Debate. The CBHSF is the location for debate. It brings together representatives from various spheres of society, various backgrounds and social classes and gives them the same rights. As an interviewee described, all can "talk" during the meetings. All of them have in theory the same chance to be elected president, or a member of the board of directors and so on. The CBHSF even funds the participation of members of civil society by covering the costs of hotels and transportation.

The SFRB Management Plan. Before approving its first ten-year water resources management plan in 2004, the committee held two phases of public meetings in different municipalities of the valley and in capital cities of the basin's states to include public input (CBHSF 2007, CBHSF 2004). The public meetings took place in: *Belo Horizonte*-MG, *Pirapora*-MG, *Ibotirama*-BA, *Juazeiro*-BA, *Maceió*-AL, *Santa Maria da Vitória*-BA, *Salgueiro*-PE and *Aracaju*-SE. A forum occurred in *Brasília* (CBHSF 2004).

Contemporary Citizen Initiated Participation – *Transposição*, the Trigger

Why is the *Transposição* here in the Public Participation Section? The ones involved in the committee recognize that the existence of the CBHSF took place due to the *Transposição*. After the approval of the 1997 Water Policy, it was illegal to allow such a project to take place without the *São Francisco* River Committee's discussion of the issue. But, besides the mandated public participation in the institutionalized form of the committee, the project has triggered strong citizen-initiated participation in and outside of the valley. Many individuals and organizations have united both against and in favor of the inter-basin water transfer project, which has elicited public support and condemnation, including two hunger strikes and various court cases. This section describes the actual *Transposição* project and some of the public reactions. In essence, this section documents the more subdued efforts of the committee expressing the mandated form of participation and the passionate efforts of the ones engaged in citizen initiated alternatives.

The need for relieving the effects of the droughts in the Northeast of Brazil inspired the original idea of the inter-basin water transfer project or *Transposição*, which is more than a century old. In the 1850s, Emperor D. Pedro II created a committee to study, among other things, the geographic aspects of the state of *Ceará*. The committee recommended the construction of a canal to link the *São Francisco* and *Jaguaribe* Rivers (Frota 1983, LARED 1995). The monarch contracted engineers to assess the SFR's navigation capabilities and to recommend ways to improve it. In 1860, one of those engineers, Henrique Halfeld, published a report which even included a map of the possible location for a canal to connect the SFR with *Ceará* and the *Rio Jaguaribe* Valley with the sea (Halfeld 1994). Recurring extreme droughts and other reasons, namely, political and electoral, the so called "drought industry" kept the idea of the project alive

into the twentieth and until today (Andrade 2002, Cavalcanti 1988, Favero and Santos 2002, MIN 2004).

As noted by Burton in the nineteenth century, Brazil has had a bias toward monumental constructions since the old days (Burton 1977). The *Transposição* will not be the first inter-basin water transfer project that takes place in the valley. For example, the *São Francisco* River already supplies sixty percent of the water used in the capital of *Sergipe*, *Aracaju*, and nearby towns and cities (Lordelo 2009, Sergipe 2003). In 2005, the National Water Agency had granted the state of Sergipe sanitation company, *Companhia de Saneamento de Sergipe* – DESO the right to withdraw a maximum of 1.7m³/s. A new resolution increased that number to 2.8 m³/s for a fifteen-year period [ANA Resolution# 164 of 2005, ANA Resolution# 265 of 2008].

According to the National Integration Ministry – MIN's Environmental Impact Assessment report, the actual project (*Projeto de Integração do Rio São Francisco com Bacias Hidrográficas do Nordeste Setentrional*) proposes to remove 3.5% of the SFR's available discharge at *Sobradinho Reservoir*, that means 63.5 m³/s (MIN 2004). The National Water Agency has selected the right for the future use of only 26.4 m³/s, 1.4% of the available discharge [ANA Resolution# 29 of 2005]. The water will leave the *Velho Chico* by two canals, North and East, respectively in *Cabrobó*, a town downstream *Petrolina*, and at *Itaparica* Reservoir, in the municipality of *Petrolândia*. Both towns are located in *Pernambuco*, downstream of *Sobradinho*. The project will involve a total of 720 kms of canals (Figure 5.4 below, see red lines) [IBAMA Previous License# 200 of 2005].[8] It will include twenty-six reservoirs, two small-scale hydropower plants and pumping stations [IBAMA Previous License# 200 of 2005, IBAMA Notice# 31 of 2005].

[8]North axis: 42.4 m³/s with withdrawal in *Cabrobó* to the following watersheds: *Rio Jaguaribe* (*Ceará*), *Rio Apodi* (*Rio Grande do Norte*), *Rio Piranhas-Açu* (*Paraíba* and *Rio Grande do Norte*) and *Rio Paraíba* (*Paraíba*) (MIN 2004). East axis: 21.1 m³/s with uptake at *Itaparica* Reservoir to river basins of *Pernambuco* state to: *Rio Moxotó*, *Terra Nova* and *Brígida* (in the SFRB) (MIN 2004).

Conflicting goals and interests exist regarding the *Transposição*. According to MIN (2004) the project seeks to increase the access to water in the semi-arid region, and to reduce uneven water availability among populations and basins of the Northeast. MIN (2004) argues that the inter-basin water transfer project will bring water to the ones without it, citing a figure of twelve million northeasterners. This view has similarities to the pre-1950s alternatives to address the phenomenon of droughts, historically named in the literature as the *hydraulic* approach, meaning bringing water to the ones without it.

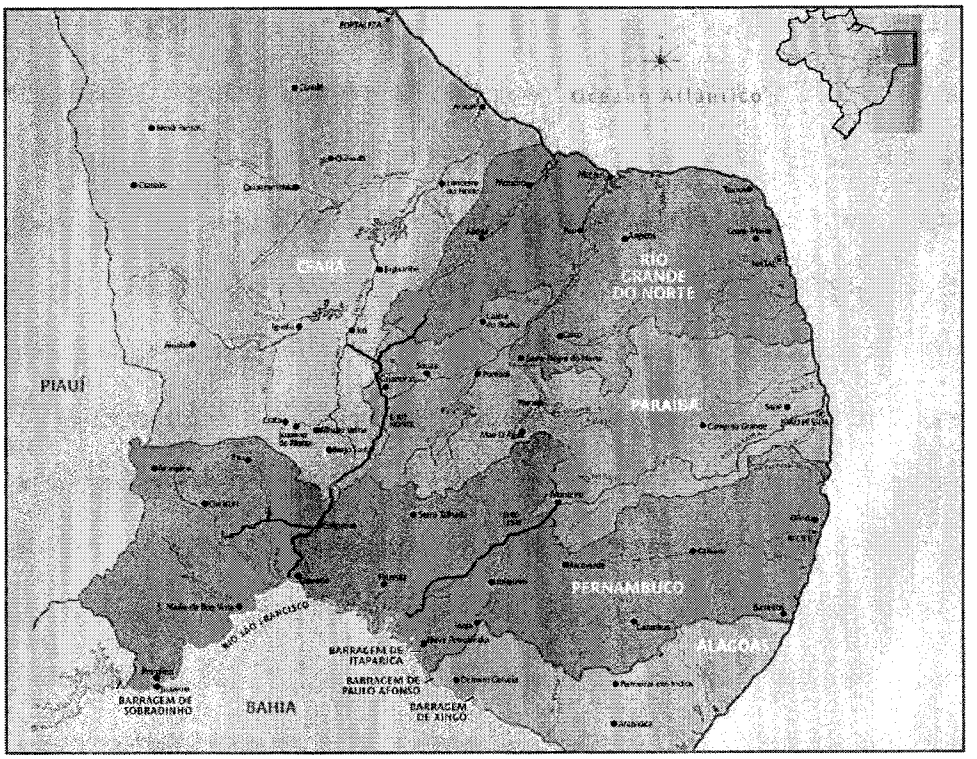

Figure 5.4. The *Transposição* (red line)
Source: modified from MIN 2004, 5.

Believers also argue that the project will spur economic development because the water will be used for economic activities, such as irrigated agriculture and aquaculture. In this regard, it follows the post-1950s theory, the *economic* one. The *Transposição* is a component of a 2007 federal development plan – Growth Aceleration Program – 2007-2010. In practice, if the project (MIN 2004) becomes what its outline

describes and the history of the area recounted in this text tells us, no one can guarantee it will deliver water to vulnerable individuals that are to the ones who need it the most: dispersed small-scale farmers in and outside the valley.

The Feasibility of the Project

In his 1938 article, Freise (1938) recognized the topographic and technological feasibility of the construction of a proposed 500 kilometer canal. But, he noted the uncertainty regarding financial support (Freise 1938). At a time when ecological sustainability was not a must, he ignored environmental and social issues in his analysis. Is such sort of project in this day and age, still "feasible" if assessed against other criteria?

MIN reported that the actual project would cost 1.5 billion dollars to be shared among the North (1.03 billion) and the East subprojects (472 million) (MIN 2004).[9] The World Bank refused to finance such a controversial project since other alternatives exist, such as improving water distribution systems to provide existing available resources (Macedo 2005). Brazilian federal money funds the *Transposição*. But, MIN could use the resources to provide other benefits for a larger share of society. In addition to the above-mentioned concern, other opportunity costs are involved, namely regarding the use of water.

In 2006 the Union Account Tribunal (*Tribunal de Contas da União*) questioned among other things the size of population that would really benefit from the project and the amount of time needed to undertake the endeavor. It asked MIN about the cost that the nation will incur to build such a scheme. It also inquired how much would be saved in drought alleviation programs due to the implementation of the *Transposição* [DOU 06 Nov, 2006, 9.1.1. and 9.1.2].

[9] The costs based upon July 1999 prices [IBAMA Notice# 031 of 2005].

The scheme will reduce CHESF's hydropower production by an estimated 2.4% (MIN 2004). According to MIN (2004), the National Water Agency – ANA established that 380 m^3/s is available for consumption until 2013, and the actual use is of 91 m^3/s. Nevertheless, if the ones who already own the right of the water employ the reserved resource, less will be available for the inter-basin project. ANA through the water use grant system had already issued warrants for other uses of the water involving a total of 335 m^3/s (CBHSF 2004) out of an available precautionary figure of 360 m^3/s (CBHSF 2004). This fact left only 25 m^3/s vacant for future uses including the *Transposição*. But ANA granted the right of use of 26.4 m^3/s for the project [ANA Resolution# 412 of 2005].

The Brazilian Environmental Institute – IBAMA has issued an environmental license for the project [Previous License# 200 of 2005], even knowing that the environmental assessment noted twenty-three high importance impacts out of forty-four total identified major effects of the project. Twelve of these 23 are negative and are listed in the Table 5.1 below (MIN 2004). For example, the *Transposição* will introduce changes into the water-receiver ecosystems."Water carries with it the imprint of its place of origin, including various types of microbial life and dissolved solids, temperature, corrosiveness, and taste" (Blatter 2001, 46). It also carries the consequences of "...the human processes to which it has been subjected" (Blatter 2001, 46). The water will bring new aquatic species to the region, including vectors of waterborne diseases. In addition, the report lists the change in the fluvial regime of the *São Francisco* River as a possible risk (MIN 2004).

Researchers have asserted that the investigation did not take into consideration other effects upon the entire donor basin because the project impacts the water body due to the withdrawal of a scarce resource. Indeed the SFRB is seen in the environmental report mostly as an area that will be indirectly influenced. Programs to compensate for the possible damages have been proposed for the areas that will receive the project

(MIN 2004). The fact implies that most of the basin will not be entitled to compensation. The inter-basin water transfer will cause even more problems than the SFR system already faces today. The water withdrawal will reduce the river's discharge into the Atlantic Ocean. This might aggravate the intrusion of salt water and ocean species back up into the SFR and cause coastal erosion. It might contribute to social problems as well. For example, the project includes resettlement schemes (MIN 2004). It might induce accelerated urbanization in infra-structure-poor cities as has taken place in *Juazeiro-Petrolina* zone.

Table 5.1. Major Negative Impacts

Negative
Temporary job loss due to land displacement
Change in the composition of aquatic communities in water receiver ecosystems
Danger of biodiversity loss in aquatic communities
Introduction of social tension and conflicts during the construction of the project
Destruction of community's socio-economic ties during the construction of the project
Possibilities of interfering with indigenous populations
Pressure over urban infrastructures
Danger of interfering with cultural patrimony
Loss and fragmentation of 430 ha of native vegetation and terrestrial species habitat
Danger of introducing fish species harmful for humans
Alteration on fishing in existing water reservoirs
Alterations of the fluvial regime of receptors watersheds

Source of data: MIN 2004

Pessoa and Galindo (1989) have identified the social effects in areas that have introduced transformations to the agricultural sector similar to the ones that the *Transposição* probably will bring about. They found that modernization of agriculture led to concentration of land and technology, and lack of participation for local people in the decisions that affect them. The project is in its implementation stage (Table 5.2 below), but problems have already arisen in the SFR valley. MIN (2004) acknowledged that the project included the mapping of indigenous populations' land in the region to prevent future conflicts. Nevertheless, it does not seem to have had positive effects. The beginning of the construction of the scheme has been taking place on indigenous

population's land, without the mandated congressional approval [1988 Constitution, Art.231, §3°]. The new governance system would also require the participation of indigenous people or the agency which supposedly protect their rights.

Table 5.2. The Timeline of the *Transposição* Project: Licenses and Grants

Date	Fact
January 2005	The National Water Agency issued a three-year preventive water use warrant selecting 26.4 m^3/s of the *São Francisco* River for the *Transposição* Project [ANA Resolution# 29 of 2005]. The number will be higher when Sobradinho reservoir is above 94% of its capacity or above the waiting volume to control flood (the smaller number of these two).
April 2005	Brazilian Environmental and Renewable Resources Institute – IBAMA issued the previous environmental license of one year for the project [IBAMA Previous License# 200 of 2005]. Construction was supposed to start in August 2005. This permit authorized the beginning of the construction of the project.[10]
September 2005	The National Water Agency issued in favor of the National Integration Ministry the water use right for a twenty-year period of 26.4m^3/s. The total needed to meet the demand for human and animal supply by 2025. This is the so called *outorga* for the *Transposição* project [ANA Resolution#411of 2005].[11] In exceptional condition, the withdrawal can be higher, when *Sobradinho* Reservoir is about 94% of its level or it presents levels above the waiting volume necessary to control floods.
September 2005	The National Water Agency issued in favor of the National Integration Ministry the permit that certifies the sustainability of the water related work – CERTOH [ANA Resolution# 412 of 2005].
March 2007	The Brazilian Environment and Renewable Resources Institute issued a license to the beginning of the construction of two segments of the North and one of the East axes of the project for a four-year period [IBAMA Implementation License# 438 of 2007].

Other issues of concern include the management of the water and of the infrastructure of the project. Even if the water does arrive in the target regions no one will guarantee that the ones who need it most will have access to it. In 2009, ANA temporarily suspended the license of the state of *Paraíba* regarding the *Transposição* because it had not undertaken proper measures to assure the future management of the water resource in its receiver basins. *Ceará* is a good model; it stands at the other

[10]The Environmental Ministry will issue a license when the project is running.
[11] *Outorga* means the permit which assures the right to use water resources.

extreme. It already has an effective inter-connected system of water management for the entire state.[12]

Why is the Project a Challenge for the CBHSF?

The Transposição shows a failure in the new participatory and decentralized model of water governance. The federal government found another alternative to undertake the endeavor, illustrating the same top-down approach of policy-making. The committee's response to the project was not the one the federal government members wanted to hear. The CBHSF first said "no". It would be necessary to create the watershed plan to assess the existing uses of the water before assigning new ones [CBHSF Deliberation# 6 of 2003]. Then the committee again said "no" to the inter-basin water transfer scheme. In this case, the CBHSF would only approve the project if the government could prove that, the water was needed to meet human and animal species consumption, the "priority" use mandated by the 1997 Water Policy. Otherwise, the resource's primary use shall be in the basin [CBHSF Deliberation# 18 of 2004, Art. 3].

But, decision-making did not stop there. The National Integration Ministry appealed the CBHSF's decision to the National Water Resources Council – CNRH. The process went all the way to the CNRH, which then approved the construction of the project [CNRH Resolution# 47 of 2005]. According to the CNRH, the committee could not

[12] *Companhia de Gestão de Recursos Hídricos* – COGERH is the state agency in charge of water resources management in *Ceará*. It exists since 1993, and started charging for water use in late 1990s (Abers and Keck 2006). The *Ceará* model of management is more centralized than in the other states. Watershed committees do exist, but have less power; as for example, the COGERH replaces the water agencies (Silva and Bezerra 2010). Besides, the state also has reservoir commissions and sub-basin committees. COGERH has played many of the roles of the federal anti-drought agency – DNOCS. But as similar to the management undertaken by that federal agency, the state still relies upon the water reservoirs systems as an alternative against the semi-arid climate and long term droughts (Formiga-Johnsson and Kemper 2008). The watershed-based entities have not much say regarding the use of the resource from water charge, but the state water council does. The resources are not necessarily employed in the basin that generates them (Abers and Keck 2006). COGERH collects the water charges and acts as the executive secretary for state committees (Formiga-Johnsson and Kemper 2008, Silva and Bezerra 2010). (The *Companhia de Água e Esgoto do Ceará* – CAGECE is the state agency in charge of water and sanitation services; the Superintendência de Obras Hidraulicas – SOHIDRA undertakes water related works; and the *Secretaria de Recursos Hidricos* – SRH is a policy-making body which has SOHIDRA and COGERH under its administrative jurisdictions.

decide on the matter because the consequences of the use of the water go beyond the boundaries of the state where the project will be implemented [1997 BWP, Art. 35, III]. Looked at from this angle, almost all the uses have effects outside state's boundaries. But the 1997 Water Policy mandates the management of basins by watershed committees [Art. 37, I]. In addition, the São Francisco Watershed Plan establishes that inter-basin water transfer projects shall take place only for human and animal supply (CBHSF 2004). The management plan is an instrument of the 1997 Water Policy for water resources governance and should be taken into consideration. In the new governance framework, the National Water Resources Council is the last level of decision-making and of conflict resolution. The CBHSF has no other instance to appeal.

The case raises issues of legitimacy, equality, and power. In the CNRH the number of members of the executive federal government cannot be more than half plus one [1997 Water Policy, Art.34, Unique Paragraph]. But governmental members form the majority in this highest order of water resources decision-making taking into consideration the various levels involved, such as state and federal (MMA *et al.* 2008a). Also regarding legitimacy, the Brazilian Environmental Institute in charge of presenting the environmental impact assessment in public meetings, did not hold all the required public meetings for various reasons, including judicial interventions and public demonstrations [IBAMA Notice# 031 of 2005].

Reaction to the project triggered different forms of participation by various sectors of the society independent from the mandated model institutionalized for the *São Francisco* by the CBHSF. For example, the environmental agency, CRA, and a non-governmental organization in the state of *Bahia*, GAMBÁ, sued IBAMA for issues concerning lack of compliance with environmental legislation and how IBAMA was handling the public meetings [IBAMA Notice# 031 of 2005].

The *Transposição* illustrates the case of a weak newly created institution. CBHSF, as many other institutions of Brazil, has no power against political interests. The National Integration Ministry is building the project even after the committee had expressed a contrary opinion.

Political Issues

The influence of politics upon the inter-basin project changes accordingly to the political figure and party in power. For example, *Gedel Vieira Lima*, once National Integration Minister shifted sides from rejection to supporting the project when he became a minister under President *Lula da Silva*. Northeast state governors stand on different sides (Fernandes 2006). In the 2006-2010 period, *Ceará*, *Paraíba*, *Pernambuco*, and *Rio Grande do Norte* governors stood in favor. Pernambuco participates as both water donor and receiver state. The position of the Bahia governor shifted from unclear to subtle support. The governors of the states of *Sergipe*, *Alagoas*, and *Minas Gerais* were against the project. Residents of those states stand on both sides of the debate too. Many average citizens from water-receiver states are in favor of the project (Alcântara 2006).

Citizen Initiated Participation

Despite what seems to be a generalized culture of non-participation, the *Transposição* has brought attention to the river and increased engagement. Legally mandated involvement is not the only form of public participation in relation to the SFR. The next sub-sections describe some of those popular expressions of citizen initiated engagement triggered by the imminent problem, the inter-basin project. The engagement of the civil society comes overwhelming from the opposition. But, important political figures have fought for the project to take place, such as President *Lula da Silva*,

a native of *Pernambuco*; and *Ciro Gomes* from *Ceará*, a former Minister of Integration who has showed enduring support for the endeavor.

The Fast

Dom Luiz Flávio Cappio, a Catholic Church Bishop has lived and worked in the Northeast of Brazil since 1974 (Coelho and Nogueira Júnior 2006). *Dom Luiz* inhabits the riparian city of *Barra*. He has long observed the close relation between the river and local populations, especially those living from fishing and traditional agriculture. He also has noticed the environmental degradation of the river system (Religious figure, PC-phone interview, 13 Jan 2007, Barra-BA). In one of his attempts to change the existing model of exploitation of the river, he spoke about the river and people's importance in protecting the waterway's resources during a one-year-pilgrimage in riparian towns from October 4 of 1992 to the same day of the following year. *Dom Luiz* opposes the proposed inter-basin water transfer project. From his residence, he sees women who live a hundred meters from the river carrying water due to the lack of access to the resource in the basin. He argues that the project will not improve the life of such people (Religious figure, PC, 13 Jan 2007). The project does not focus on water access and on the expansion of a water distribution system as it should ethically do (Cappio 2006). *Transposição* involves different dimensions: technical, "ecological, economic, social and ethical" (Laura 2007b).

In September 26, 2005, Dom Luiz started a hunger strike in Cabrobó, *Pernambuco*. Until he ended on October 6, 2005, the *São Francisco* River was always in the news. The bishop temporarily stopped an eleven-day fast after President *Lula* promised reopening the issue of *Transposição* to public discussion (Nascimento 2007). But the Catholic hierarchy had not supported the hunger strike (Coelho and Nogueira Júnior 2006). Suicide is against the church's rules. But, international, national and community members

of the churches showed support. For example, parishes printed *Dom Luiz*'s letter to the people of Northeast in their newspapers (Arquidiocese de São Salvador, 06 Oct 2005). Members gathered in religious celebrations and participated in public demonstrations.

After two years of unsuccessful dialogue regarding the project, with few attempts to reopen the channel of communication, and with the project's plans moving forward, the bishop took a second step.[13] In November 27, 2007, he resumed his fasting, this time in a chapel of the town of *Sobradinho, Bahia*, for twenty-four days seeking what he called "real democracy" (Cappio 2007). At the time of this hunger strike, the reservoir had only fourteen percent of its capacity (Nascimento 2007). Dom Luiz (Cappio 2007) restated that the project would not improve local residents' lives. It would not increase their access to water.

As in the first hunger strike, besides the assistance from Pastoral Land Commission, a partner in the endeavor, the hunger strike received support from fishermen, farmers, landless workers, and many others. Domestic and international supporters virtually or in person stood on the side of *Dom Luiz*. Public demonstrations took various forms. He received letters and phone calls of encouragement (e.g., from the Franciscan Order's superior general in Rome) (Laura 2007d). Public support also included visits of religious figures, senators, deputies, and artists. Religious ceremonies such as processions brought together in *Sobradinho* thousands people from the different states of Brazil (Laura 2007c) (Figure 5.5 below). In the middle-SFR protesters from social organizations blocked traffic on the bridge over the SFR (Hermes 2007). In Salvador, demonstrators from the *Fórum de Defesa* (described below) showed their support for the bishop in the city's historic district. The encouragement for the hunger strike and restoration of the *Velho Chico* included broad sectors of society. The CBHSF also showed solidarity with the bishop's hunger strike.

[13] In December 2005, President *Lula da Silva* met *Dom Luiz Cappio* and a negotiation committee. In July 2006, besides the bishop, members of the civil society and federal government met and created three working groups to study issues such as water availability, alternatives for the development of the semi-arid and SFR restoration.

Nonetheless, on December 19th, the Bishop ended his second fast after learning of the decision of the judicial Federal Supreme Court to allow the *Transposição*.

Figure 5.5. *Dom Luiz* Cappio
Source: Ivan Cruz/Ag. A Tarde, 04 Dez 2007.

Fórum de Defesa

The *Fórum Permanente de Defesa do Rio São Francisco* is a group of civil organizations united to protect the waterway. It came into being as a result of the opposition of social movements against the *Transposição* project. It includes over sixty entities. Members range from professional organizations such as of engineers and the *Bahia* university professors' association, church organizations such as Caritas, and the Pastoral Land Commission. It is an example of civil action and participation. It has engaged the public against the project in different ways. For example, on January 11, 2007, the *Forum de Defesa do São Francisco* protested against the inter-basin water transfer project during a large popular traditional Bahian cultural event, *Lavagem do Bonfim*, which occurs every year in *Salvador*. The group met early in the morning and brought banners and a huge model of a fish, *Surubim*, a species of the river. The group

walked through the streets for hours. Again, on February 2, 2007, the group repeated the protest to bring attention to the problems of the river, but this time at the *Yemanja* (Sea Goddess) annual celebration also in *Salvador*. The group requested *Yemanja*'s protection for the river. The *Forum* brought the fish, a gift-basket to *Yemanja* as many do in that celebration; banners and pamphlets, which stated the *Forum*'s opposition to the scheme.

The citizen initiated movement also used news tools. In 2004, the *Forum* requested from the SFRB committee an assessment of the conflict of use that the inter-basin project would bring [CBHSF Deliberation# 19 of 2004]. The committee has not provided an answer yet. The *Forum* also used the judicial system to fight again the *Transposição*. For example, in 2005, it required the halting of the environmental license process of the project undertaken by the Environmental Institute. In 2007, the *Forum* appealed a Federal Supreme Court's ruling which had eliminated all the decisions that had temporarily halted the project thereby allowing its construction.[14]

Camping in Brasília

About six hundred people representing the four sub-regions of the basin, and also other areas of the country, such as organizations from the state of *Ceará*, set up a camping ground in Brasília, from March 12 to 16 of 2007. The group promoted demonstrations, workshops, and participated in a public meeting of the Federal Supreme Court to demonstrate their opposition to the inter-basin water transfer project.

Summary and Transition to Next chapter

This chapter teaches us that, dams, other large scale infrastructures and the federal government's intransigency are still the perceived threats to the *São Francisco*

[14] About eleven complaints against the project were under the evaluation of the Supreme Federal Court. States (e.g., *Bahia*), nongovernmental organizations (e.g., *Fórum de Defesa*, lawyers associations) had brought the issue to court.

and the basin's population. Nonetheless, those pressures also trigger engagement. Despite the newly mandated institutionalized mode of participation, citizen initiated forums still take place in the valley. Initiatives now also focus on the river's water, differently from in the past where water was one issue on a longer list, when on the list at all, among many other demands. Citizen initiated participation has not been able to stop, but it has successfully delayed, the construction of the project. A bishop of the Catholic Church undertook two hunger strikes, the social movement disturbed public meetings taking place and brought more awareness to the project than the government certainly would have done. In addition, the social movements questioned the real need for the project: who and what sectors of society and economy would benefit from it and the river's capability to supply the service? The next chapter describes life in seven municipalities of the basin justifying why local residents should be and are worried about this new federal government intervention. After the construction and operation of the project no one can be sure that the *São Francisco* River will have enough water to meet the demands of local populations and the ecosystem.

CHAPTER VI

A CLOSER VIEW OF SEVEN MUNICIPALITIES OF THE BASIN - THEIR TRANSFORMED ENVIRONMENT AND SOCIO-ECONOMIC CONTEXTS

> Many meanings of water are currently invoked in debates about water policy: Water is a physical/chemical resource; it is a tangible substance. Water is also imbued with various meanings that are socially constructed. Water has economic value; it is a subsistence resource, a component of national security, and a focal point of identity. (Blatter *et al.* 2001, 34)

In the context of the statement above, the objective of this chapter is to provide a closer view of the changing role the *Velho Chico* has played in the life of the region's inhabitants. What does the river's water mean to local people? This chapter documents the change in the human-environment relationship as well. In this section, I used data from observations, interviews, and the existing literature to build the environmental history of selected cities and towns to help us understand how these places were in the late 1940s-early fifties and how they became what they are today.[1] This chapter describes selected cities and towns' important uses of the river, and how environmental and socio-economic changes have influenced those municipalities.[2]

Dams were not the only cause of transformations for those municipalities during the timeframe studied. Urbanization and road construction were major influences in the life of the populations of these seven and of other municipalities of the basin living in a changing environment. The meanings of the river imposed by those external to the *São*

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[1] This section presents informant's perspectives and their base values, and not observer's bias. The case studies were a device to include their view on local (ecological and socio-economic) changes.

[2] The section for each municipality varies in length. It depended on the available literature and on primary data collected. I applied the same structure for each place, but some will not provide information under some headings.

Francisco System influenced the pace of the environmental changes. This chapter showed how local people have coped with those alterations.

Municipalities are the lowest hierarchical level in the administrative governmental structure of the Federative Republic of Brazil. But municipalities can include sub-units – districts. A city is the urban zone of the district which houses the municipality's administrative headquarters (Lima (org) *et al.* 2002). This research uses the term "city" to refer to municipalities that include the headquarters of its government, contain large urban agglomerations and numbers of residents, and economic activities serving as the commercial center for neighboring towns. It applies the word "town" to describe the municipalities with smaller urban areas, population and level of economic actions. The expression "village" means an administrative unit without a town or a city and with a small number of inhabitants.

The Seven Municipalities: Cities and Towns

Extensive cattle ranching was the earliest occupation of the valley. Nevertheless, urban growth started especially during the XVIII century (Azevedo 1968, vol. 2). Towns grew for various reasons (IBGE 1960b). In the *Sertão*, cities and towns expanded along rivers and in other humid places such as nearby small mountain ridges (IBGE 1960b). Settlements grew in proximity to geographic accidents (e.g., waterfalls) and at transshipment points: *Pirapora* (Deffontaines 1938). They also arose at river crossings: *Petrolina* and *Juazeiro*. Urban zones developed along or at the final destination of communication systems such as mule cargo trails, cattle routes, waterways, unpaved roads, and railroads (Deffontaines 1938, IBGE 1960, Neves 2006, Machado 2002).[3] In addition, transportation networks were a major cause of city creation in the nation

[3] In his 1998 book, Zanoni Neves describes the growth of cities in the meeting point of hydro-road-railway systems. Still, they experienced a larger economic, but not necessarily social development (Neves 1998).

(Deffontaines 1938). But, it has also led to the decline of cities in cases of changing transportation means and routes, as in the case of *Pirapora*.

Religious beliefs also have triggered the existence and growth of cities (IBGE 1960b). *Bom Jesus da Lapa* expanded around a pilgrimage site. *Juazeiro* originally resulted from a *Capuchin* mission. Large cities emerge as commercial nodes. They can also influence the expansion of others. *Petrolina* grew due to *Juazeiro*'s regional influence (Azevedo 1968, vol. 2).

Several factors drive the development of secondary cities, but their maintenance and future growth depends upon their diversification, commerce, and trade capability (Rondinelli 1983a). Access to water influences economic activities too. *Petrolina* and *Juazeiro* are good examples. They became centers for hydro-businesses such as irrigated agriculture and the services that support that activity. The two cities serve as a hub for functions not provided in other localities of the area, such as banking, health and educational services.

City growth did not mean equitable spatial development. According to Rondinelli (1983a), a city can drain resources from rural areas and not re-distribute the benefits among the majority of regional inhabitants. In addition, large urban agglomerations can centralize pressure on the local environment (e.g., sewage). The Figure 6.1 below shows the location and Table 6.1 below provides a summary of the seven municipalities under study.

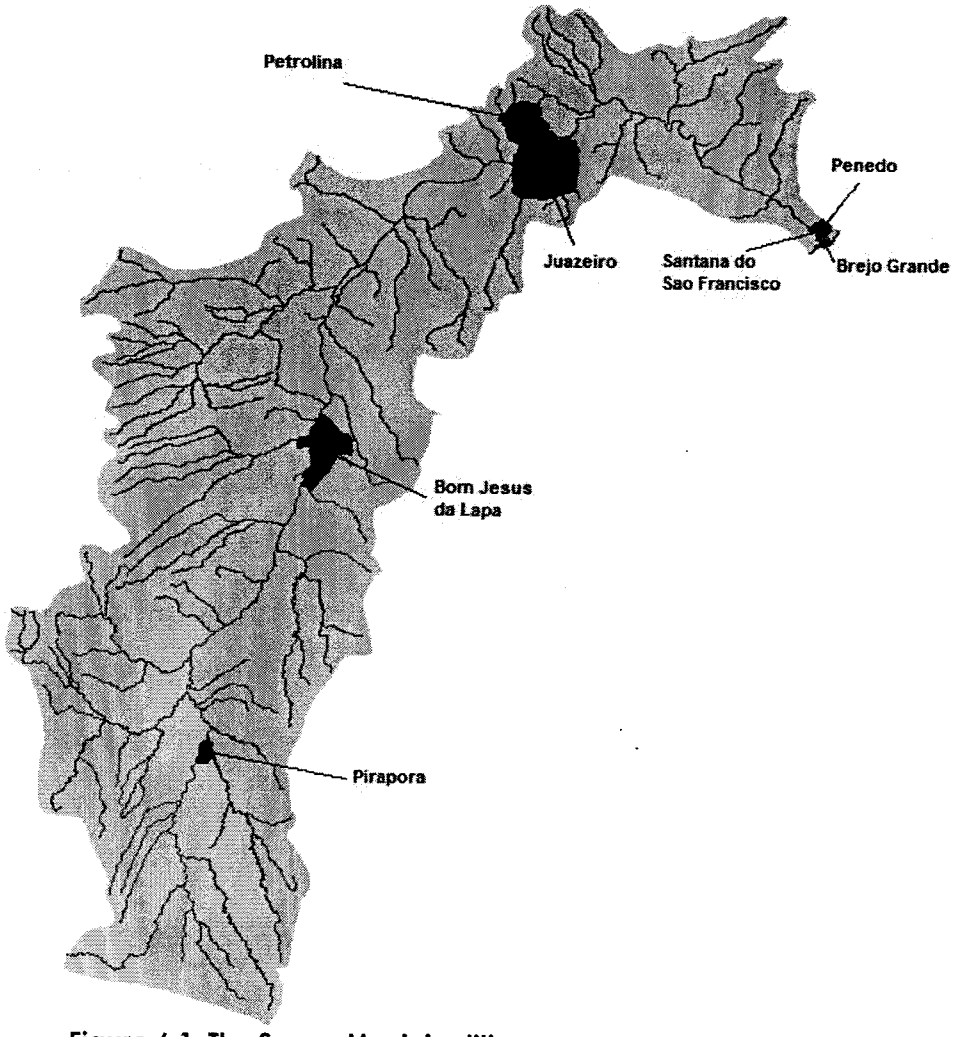

Figure 6.1. The Seven Municipalities
Source: derived from geo-referenced data from ANA Hydroweb visited on 03 September 2009 (ANA 2009).

In the late 1940s-early 1950s, the economy of the municipalities of the valley was based upon herding, agriculture, gathering, and on a much smaller scale manufacturing (Pierson 1952, vol. 3). In addition, fishing was an important subsistence activity though as this chapter describes, in cultural and economic terms more crucial in some localities than in others. In general regards, navigation was essential throughout the SFR valley, especially from *Pirapora* to *Juazeiro-Petrolina* and in the lower-SFR.

Table 6.1. The Seven Municipalities – A Summary

City Reach of the River (State)	A Municipality Since	Area in km² Population HDI in 2000 % Water coverage Major Source % Sanitation Cover % Garbage Collection	Biome	Major Economic Activities	Major Uses of the River
Pirapora – limit between the Upper and Middle-SFR (Minas Gerais)	1911	575 km² 1950:9,632 2007:51,636 HDI: 0.758 Water: 98.7% Major source of drinking water: SFR Sanitation: 4.5% Garbage: 95.3%	Savannah	Past: commerce, port, fishing Present: industry, commerce	Past: navigation, fishing, natural fertilization, public water supply sanitation Present: agriculture, public water supply, industry, sanitation
Bom Jesus da Lapa – Middle-SFR (Bahia)	1923	3,951 km² 1950:14,035 2007:62,199 HDI: 0.654 Water: 98.6% Major source of drinking water: SFR Sanitation: 9.4% Garbage: 64.3%	Savannah and Steppe	Past: religious tourism, commerce, agriculture, herding, fishing, Present: religious tourism, commerce, agriculture, herding, fishing	Past: transportation , water supply, religious purpose, sanitation Present: agriculture-irrigation, public water supply, sanitation
Juazeiro – Lower-Middle - SFR (Bahia)	1878	6,390 km² 1950: 19,820 2007: 230,538 HDI: 0.683 Water: 96.2% Major source of drinking water: SFR Sanitation: 76.5% Garbage: 78.8%	Steppe	Past: Commerce port Present: irrigated agriculture, commerce	Past: navigation, fishing, public water supply, sanitation Present: irrigation, public water supply, sanitation

Table 6.1.*Continued*

City Reach of the River (State)	A Municipality Since	Area in km² Population HDI in 2000 % Water coverage Major Source % Sanitation Cover % Garbage Collection	Biome	Major Economic Activities	Major Uses of the River
Petrolina – Lower-Middle - SFR (Pernambuco)	1895	4, 559 km² 1950: 6,500 2007: 268,339 HDI: 0.747 Water: 97.8% Major source of drinking water: SFR Sanitation: 87.1% Garbage: 92.8%	Steppe	Past: commerce Present: irrigated agriculture, commerce	Past: navigation, public water supply, sanitation Present: irrigation, public water supply, sanitation
Penedo – Lower-SFR (Alagoas)	1842	689 km² 1950: 20,762 2007:59,020 HDI: 0.665 Water: 93.7% Major source of drinking water: SFR Sanitation: 17.8% Garbage: 95.5%	Steppe and Atlantic Rainforest	Past: fishing, agriculture, port, commerce Present: commerce, tourism, agriculture	Past: agriculture, navigation fishing, natural fertilization, public water supply, sanitation Present: irrigated agriculture, navigation for locals, fishing, public water supply, sanitation
Santana do São Francisco – Lower-SFR *(Sergipe)*	1991	46 km² 1950:1,400 (urban zone) 2007: 6,596 HDI: 0.579 Water: 93.2% Major source of drinking water: groundwater Sanitation: 87.9% Garbage: 86.6%	Atlantic Rainforest	Past: pottery, agriculture fishing Present: pottery, agriculture fishing	Past: navigation fishing, natural fertilization, public water supply, sanitation Present: navigation, fishing, irrigated agriculture, sanitation

Table 6.1.*Continued*

City Reach of the River (State)	A Municipality Since	Area in km² Population HDI in 2000 % Water coverage Major Source % Sanitation Cover % Garbage Collection[4]	Biome	Major Economic Activities	Major Uses of the River
Brejo Grande – Lower-SFR (*Sergipe*)	1926	150 km² 1950: 10,732 (2,000 district) 2007: 7,760 HDI: 0.55 Water: 80.3% Major source of drinking water: groundwater Sanitation: 2% Garbage: 68.5%	Atlantic Rainforest	Past: agriculture, fishing Present: agriculture, fishing, aquiculture	Past: agriculture, navigation, fishing, public water supply, sanitation Present: agriculture, fishing, aquiculture, sanitation, navigation for locals

Improved water supply systems over time have provided a greater spatial distribution of water among the population than the archaic methods employed during the early years when users and providers carried the water, and demand was much smaller. The *Velho Chico*, tributaries and wells supplied towns and cities. Irrigated agriculture has replaced most of the traditional agriculture of the past.[5] Despite the consequences, dams have produced a steady source of hydropower that has no doubt benefited those with access.

[4] The Human Development Index – HDI, as its name says, is a general measure of human development. It is based equally on three indicators: the per capita GDP after taking into consideration the purchase power of each nation; the life expectancy at birth and the level of education (PNUD 2000a). The average HDI is between 0.5 and 0.8 (PNUD 2000). The average for Brazil is of 0.766. Note: percentage of homes in urban zone linked to city's water network system (2000 Census) and major source of water; percentage of homes in urban zone linked to city's sanitation network or improved septic systems (2000 Census), and percentage of homes in urban zones with access to garbage collection (2000 Census).

[5] New crops have been introduced.

***Pirapora* the Limit between Upper and Middle-São Francisco: the Place Where Fish used to Jump**

Introduction. After a one hour and a half flight from *Salvador* to *Belo Horizonte* and a five-hour bus trip from *Belo Horizonte*, I arrived in *Pirapora*. It was still day light and I was anxious to see how different the river really is in this municipality, as described by many. A series of small falls creates a sound that one can hear from far away and announces the city (Sampaio 2002). The river sounds very active here. But during my two visits to *Paulo Afonso*, in the lower-middle-SFR, I did not have the pleasure of seeing the waters of the *Paulo Afonso* Falls or of hearing the falls' music because the river was "dominated" ("*dominado*"). Local people use that word to express human control through damming of the waterway over the forces of nature.

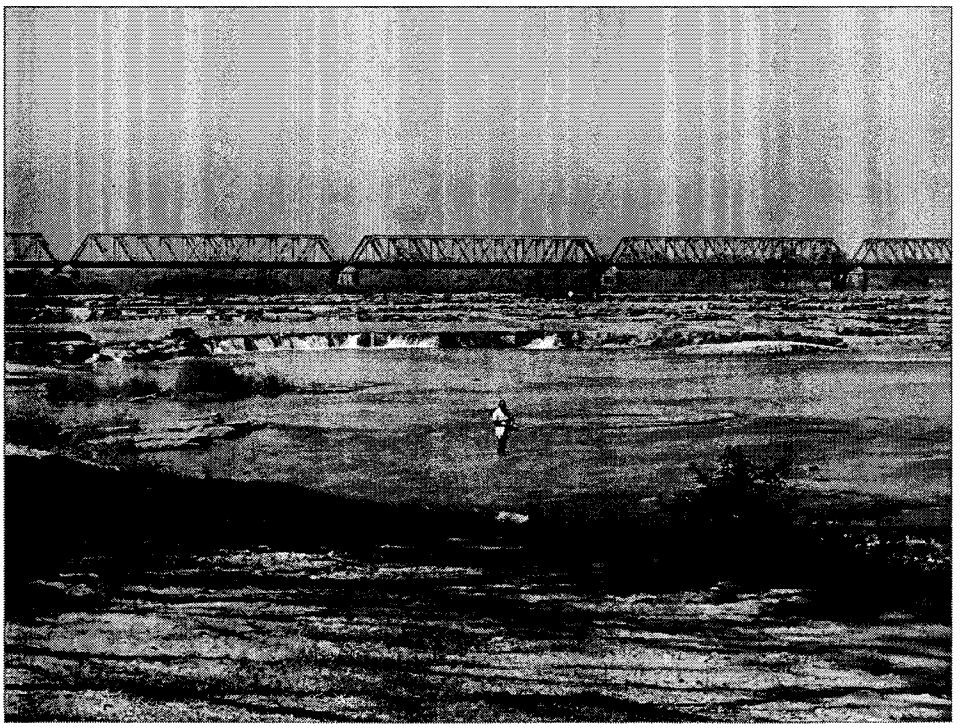

Figure 6.2. *Pirapora* Falls
Source: Lucigleide Nascimento 2007

The *Velho Chico* is unusual in this stretch (Figure 6.2 above). "[I]n Pirapora itself, the river becomes noisy and turbulent as its waters run through the rocks. After the rocky

segment, the river again runs smoothly, as it does for most of its 1,800 miles course" (Bouquet 1967, 81). The falls have two major sections. Continuous and isolated rocks diagonally cross *Velho Chico's* bed (Burton 1869). Halfeld and Sampaio measured a difference of about six meters between the upper and lower levels of the watercourse in the falls region (Sampaio 2002). The water going over the falls and scattered rocks along the river's canal also gives a lively image to the waterway.

The term *Pirapora* comes from *Pirá-Poré*, which in the indigenous *Tupi* language means place where fish jump (IBGE 1959). Fishing has been an important social and economic activity for this riverside town. Nevertheless, among other environmental changes, fewer fish jump in this region. *Pirapora* now means the place where many fish used to jump. Historic accounts about the *São Francisco* River describe a rich river environment with abundant and delicious fish, sold fresh or salted (Miranda 1936; Pierson 1972, vol.1). The city's existence relates directly to the watercourse. For centuries, the river transported people and goods (Valverde 1944b). *Pirapora* arose as a node where forms of transportation changed. River-based transport gave way to land-based ones.

Pirapora, as a municipality, dates back to 1911 (CODEVASF 2001). It is located 330 kms from *Belo Horizonte*, the capital of *Minas Gerais*, and 530 kms from *Brasília*, the nation's capital (Silva *et al.* 2000). *Pirapora* is a 575 square kilometers large city (IBGE 2009a). The city is 472 meters above sea level (Silva 1985). It is situated between the upper and middle-SFR, in the beginning of what used to be the longest navigable stretch of the River of National Unity with a length of 1,371 km (Lacerda 2004) (Figure 6.1 above). Several rapids exists upstream *Pirapora* (Burton 1869, 1977). The city is also part of the *Rio das Velhas* Basin, an important tributary of the *São Francisco*. The existence of an obstacle to navigation, the *Rapids of Pirapora* or *Pirapora Waterfalls* (*Cachoeiras de Pirapora*) triggered the growth of the village as a resting place, before undertaking the next challenge of the trip (Valverde 1944b). Looking beyond the river, ones see *Buritizeiro*

established on the west bank of the *Velho Chico*. The town was once under *Pirapora*'s administrative jurisdiction. *São Francisco of Pirapora* (*São Francisco de Pirapora*) is its former name. It became an independent *municipality* in 1962 (CODEVASF 2001).

In the beginning of the 20th century, a private company, *Companhia Cedro e Cachoeira* opened routes for steamboat navigation with the middle reach of the river (Valverde 1944, IBGE 1960, Silva *et al.* 2000). In 1902, steamers (e.g., *Saldanha Marinho, Mata Machado*) started regular service from the town (Pirapora n.d.). Large privately owned sailboats (*saveiros, barcas*), also powered by oarsmen (*remeiros*), complemented the steamboats (*gaiolas* or *vapor*) (Bahia Illustrada 1919; Historian, PC, 17 May 2007, *Pirapora*-MG).

By the middle 20th century, Pirapora was well located as a port and commercial city. It was a transportation hub. "A lot of commerce" took place there (Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). A railroad connected the valley with the outside 'developed' world (Azevedo 1968, vol. 1). The *Central do Brasil* Railroad linked *Pirapora* to *Rio de Janeiro*; the *São Francisco* waterway connected *Pirapora* to the river towns all the way to *Juazeiro* and *Petrolina*; and the *Estrada de Ferro Bahia – São Francisco* railroad linked *Juazeiro* to the coastal city of *Salvador da Bahia*.[6] The *Guanabara-Minas Gerais-São Paulo* composed the "Core Area" of the country.[7] The zone produced among others coffee, sugar-cane, and cotton (Azevedo 1968, vol. 1). The *São Francisco* and *Sertão* regions exported raw materials and received industrialized and food products.

In 1950, *Pirapora* had a small population of 9,632 inhabitants (IBGE 1950+). *Piraporenses* are those born in *Pirapora*. Nevertheless, many people came and went...

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[6] According to President Nilo Peçanha's address to the Brazilian Congress, *Central do Brasil* Railroad met the *São Francisco* River in 1910 (Rodrigues 1961). The train station started to operate in May of that same year (Valverde 1944b). The railroad went all the way to the port. A railroad bridge of 694 meters long extends over the *São Francisco* River (IBGE 1960, Silva *et al.* 2000). A Brazilian president, Epitácio Pessoa, opened the Marechal Hermes Bridge in 1922 (IBGE 1959). It was part of the failed attempt to link *Rio de Janeiro* to *Belém do Pará* by railroad (Silva *et al.* 2000).
[7] In 1974, *Guanabara* and *Rio de Janeiro* became one state, *Rio de Janeiro*.

"People going to *Juazeiro* and people from the Northeast en route to *São Paulo* looking for job" (Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). The important town housed passengers of boats and railroad in its many hotels and boarding houses (IBGE 1959). The railroad transported frozen fish out of the town. "*Pirapora* was a small place, with a lot of green" (Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). *Pirapora* attracted workers to its major industry, navigation (steamship staff 3, PC, 16 May 2007, *Pirapora*-MG). The town consisted of two parts: the lower, a residential, commercial and port; and the upper, a residential area (Lopes 1951).

The access nationwide still needed to be improved. In 1965, the entire country only had 34,636 kms of railroad. Only 26,546 out of the 803,068 kms of roads were paved. The total railroad and road extensions for the United States were respectively of 362,000 kms and 15.5 million kilometers (Azevedo 1968, vol. 1). River navigation and animals were important means of transportation in the valley (IBGE 1960; Pierson 1972, vol. 3). The *São Francisco* River has provided environmental services such as fishing and navigation to *Pirapora*'s inhabitants.

Pirapora's industrial sector was modest in the 1950s and 1960s. Manufacturing involved processing cotton, making cottonseed oil, and producing soap from *babaçu* (*Attalea speciosa*) (Zarur 1946). In 1954, *Pirapora* had sixteen factories (Engenheiros 1957). In late 1960s, the town still had a strong connection with the river; of 876 people working in industries, 740 worked for a navigation company, *Companhia de Navegação do São Francisco*. *Buritizeiro*, *Lassance* and other neighboring towns fulfilled *Pirapora*'s agricultural demands (IBGE 1960, Silva *et al.* 2000).

The River Environment. *Pirapora* has a hot humid climate, and savannah (*Cerrado*) is the predominant biome. The average annual temperature is between 73 and 75° F. Precipitation is irregular, occurring mostly between November and March;

average rains amount to 35.5 to 51 inches per year (Pirapora n.d.b). *Pirapora*'s entire territory is in the SFR valley.

Pirapora's relationship with the river has changed over time, but it is still an important element in the city's life. In the past, the population dealt more with periodic floods, which inundated riparian lagoons they used for fishing and to extract clay to make bricks (Valverde 1944b). Even now, many living along that waterway's banks could not imagine life without it. The *São Francisco* is their "left and right arms" (Fishermen 1, PC, 18 May 2007, *Pirapora*-MG). An interviewee explained that, we "...would be crazy without the *São Francisco*. [They]... would do nothing. There is no life without the *São Francisco*. The *São Francisco River* is [their] ... own life" (Clothes washer 2, PC, 16 May 2007, *Pirapora*-MG).

Pirapora's inhabitants report the meaning of the stream in ecological, economic, social and even religious ways. The *Velho Chico* is the "soul" of the ones who inhabit its riparian zone and a "national beauty" (Historian, PC, 17 May 2007, *Pirapora*-MG; Steamship staff 2, PC, 16 May 2007, *Pirapora*-MG). It is a "source of work," and of "[economic] sustainability ... because it attracts investments" (Fishermen Association's staff, PC, 15 May 2007, *Pirapora*-MG; NGO member, PC, 16 May 2007, *Pirapora*-MG). But, for this interviewee and under an ecosystem approach of management, ecological criteria should guide and define the river's uses, and that has not been happening. Environmental criteria have fallen behind political and economic considerations (NGO member, PC, 16 May 2007, *Pirapora*-MG).

In summary, navigation and fishing have supported many (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). In 2007, *Pirapora* was partially dependent on the river, while in the past it was exclusively so (Historian, PC, 17 May 2007, *Pirapora*-MG).

Has 'development' around and in *Pirapora* been economically and socially sustainable? According to Clark (2002), environmental problems result from human

activities. Natural resources management towards sustainability will have to deal with changing environment and human systems (Clark 2002).

Causes of Environmental Degradation. Several factors have disturbed fishing. The construction and operation of *Três Marias* Dam reduced fish populations downstream by interfering with the fish reproductive cycle. The dam has prevented the flooding of riparian lagoons used as fish growth sites (Alvim and Peret 2004) and the inundation of floodplains. Interviewees' personal memories and information passed through family members and others from different generations, describe a past with lagoons full of fish (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). The lack of periodic inundations also inhibits the ability of fish to enter and exit riparian lakes (Gutberlet and Seixas 2003). The lack of overflowing isolates lagoons from the river's main canal for long periods and grown migratory fish cannot return to spawn (Pompeu and Godinho 2006). The dam itself impairs fish migration. Some species, such as *Dourado* (*Salminus spp.*), *Surubim* (*Pseudoplatystoma spp.*), *Matrinxã* (*Brycon melanopterus*), *Pirá* (*Conorhynchus conirostris*), *Piau-verdadeiro* (Piau: *Leporinus spp*) and *Curimatã* (*Prochilodus spp*) are migratory and seek to return to their spawning grounds (Gutberlet and Seixas 2003). "Damming directly affects the fish communities, because its changes on the river's flow regimes cause a higher frequency of extended periods without flooding" (Pompeu and Godinho 2006, 428).

Migratory species are more abundant in the central *São Francisco* River and in the 1980s, they represented 96% of the reported total caught (Sato and Godinho 2003). This percentage shows how the effect on this category of fish can afflict fishing in general. Rainfall still maintains some lagoons, but not as many as previously (Fishermen 1, PC, 18 May 2007, *Pirapora*-MG). In 1998-99 analysts found that *Surubim* catfish

reproduced in the region during periods of high rainfall and turbidity (Brito and Bazzoli 2003), as this species needs flooding.[8]

The loss of riparian forests has also affected upper river fish species. Some species depended directly on floods for food: leaves, flowers, fruits and seeds (Alvim and Peret 2004). Besides the vegetation naturally falling into the watercourse, floods bring food into water bodies such as organic and inorganic sediment. Unfortunately, today they also bring contaminants in from the different land uses throughout the watershed.

Water pollution from domestic and industrial sewage, mining activities, and agriculture creates uncountable environmental and social damage. The National Water Agency granted the right to the city's sewage management company, *Sistema Autônomo de Água e Esgoto* – SAAE, to discharge for a twenty-year period an average of 177.64 L/s of treated sewage into the *Velho Chico* under parameters of quality pre-established [ANA Resolution# 370 of 2004, Art. 1]. But until 2009, the treatment of sewage did not exist in *Pirapora*. About 90% of the population uses precarious septic systems, cesspits (Water Treatment Plant Staff, PC, 15 May 2007, *Pirapora*-MG). Only 4.5% of the population is either linked to the city network which does not necessarily treat the sewage or to an improved septic system (IBGE 2000b). Sewage discharged into a canalized brook, *Entre Rios*, crosses *Pirapora* and ends up in the *Velho Chico*'s waters (Johnsen 2004, Igam 2008). The population also releases sewage in storm drains (Correio dos Estados & Municípios 2006). A station, located in the industrial district, collects sewage, but does not treat it (Water Treatment Plant Staff, PC, 15 May 2007, *Pirapora*-MG). The city is building a treatment plant for domestic sewage.

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[8] *Surubim* catfish, *Pseudoplatystoma coruscans*, is also known as "*moleque*" (Brito and Bazzoli 2003, Alvim and Peret 2004) and as "*pintado*" in other regions of Brazil (Brito and Bazzoli 2003). *Surubim* feed on other fish; it is a piscivorous species (Brito and Bazzoli 2003 citing Marques, 1993). In the SFR, the catch of *Surubim* has decreased from 86.3% in 1987 to 27% in 1999 (Brito and Bazzoli 2003 citing Godinho *et al.*, 2001). *Surubim* has external fertilization and the spawn, or "*carujo*," "occurs on the surface of the water, in a lotic environment (Brito and Bazzoli 2003). *Carujo* means the breeding phenomenon (Sato and Godinho 2003).

According to Correio dos Estados & Municípios (2006), industrial sewage is not the city's responsibility. Industry should be liable for it. Nevertheless, no one treats it. But, a local government decree [Decree # 16 of 2009, VI, art. 49] regulates sewage discharge into the public sewage treatment plan, including volume, type and characteristics of the waste it will treat. The future will show if the measure will be enforced or not. A municipal hospital pioneered and built its own sewage treatment station.

Sewage is not the only environmental problem. Municipal garbage collection started in 1937 (Silva *et al.* 2000). By the early 1950s, an American sanitary engineer, Herman Baity observed that, "the garbage and refuse collection service provided by the town is very irregular and inadequate. Materials are thrown on to the surface of the ground in the outlying areas" (Baity 1951, 23). In the present day, some 95% of the homes in urban zones have access to waste collection (IBGE 2009b). In 2008, the city produced almost 30 tons of waste daily (Pirapora 2008). Since 1999, *Pirapora* has a recycling program, and a recycler association (Silva *et al.* 2000). But, the city needs environmental education, as people still dump garbage into the river (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG).

Industrial and mining pollution kills fish (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG; Fishermen 1, PC, 18 May 2007, *Pirapora*-MG). Between October 2004 and September 2005, twenty-five tons of fish died in the stretch from *Três Marias* to *Pirapora* (Galdino n.d., Dumont 2007). The cause was chemical leakage (e.g. zinc) from *Votorantim Metais e Zinco S.A. (Companhia Mineira de Metais – CMM)* in *Três Marias* into the *São Francisco* and its tributaries (Galdino n.d., Dumont 2007).[9] Fish mortality still happens on a smaller scale today (2007) (NGO member, PC, 16 May 2007, *Pirapora*-MG). Fishermen have taken the case to court. The problem and its effects are a long

[9] The Companhia Mineira de Metais – CMM has a long legacy of contamination. It started to produce zinc in 1969. In 1996, CMM started to make sulfuric acid, an input to zinc production (Goncalves Neto 2001).

term issue. In the early 1970s, a report mentioned the contamination and the consequences upon fish (Development and Resources Corporation 1974b).

Another form of chemical contamination is particle deposition caused by highly visible air pollution from factories in Pirapora (e.g., from the companies *Minasliga*, *Liasa* and *Inonibrás*) (Johnsen 2004) (Figure 6.3 below). Local residents have complained about the effects of air pollution and particle deposition upon their health (e.g., skin, eyes and respiratory problems). Not all factories in the town have taken steps to improve the quality of the air in the region (CNR-COPAM-MG 2009). Air pollution probably affects fish and other aquatic species.

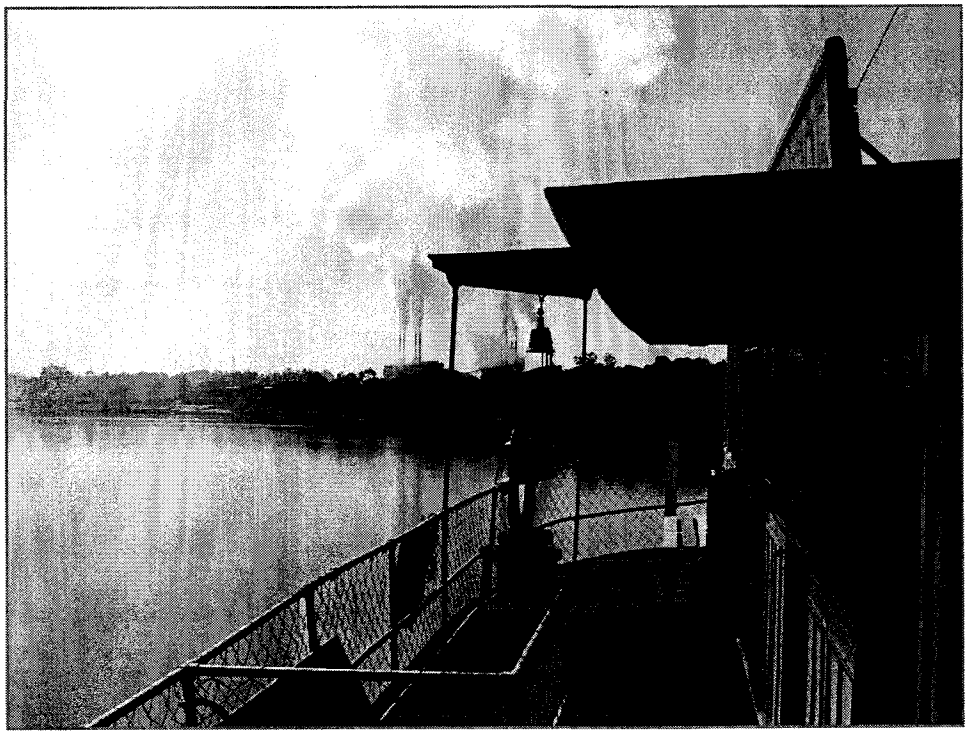

Figure 6.3. Air Pollution
Source: Lucigleide Nascimento 2007.

Agriculture and Other Non-point Source of Pollution. Interviewees mentioned that organic agriculture was practiced by prior generations in riparian zones (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). Sediments carried by the waters during floods irrigated

the land. Agriculture was small-scale and the farmer had ties to the land (Historian, PC, 17 May 2007, *Pirapora*-MG). The farmers needed to observe nature's flow, the water subsidence, to know when to farm. The construction of the dam and the subsequent control of the waters impaired this type of agriculture (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). But, irrigation created new possibilities for those with access to it. Water scarcity is a serious problem for agriculture and ranching in the region (IBGE 2005b).

Both, scientific and traditional knowledge recognize that agriculture is a high source of sediments, nutrients and agro-toxins for water bodies (CAST 1992). An angler returning from fishing with an empty basket reported that the cause of his failed day was the crop farms along the river. The increase in commercial irrigated agriculture has intensified sediment load to water. Indeed, in the past it was possible to see a lot of natural vegetation and agricultural fields were rare (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). In *Buritizeiro*, agri-businesses were sources of sediment, and were drying up brooks and streams (Navigation staff, PC, 17 May 2007, *Pirapora*-MG). They were also the source of agro-toxins and nutrients (Igam 2008). *Buritizeiro* produces soybeans, coffee and other crops. In 2007, agriculture accounted for some 90% of the surface water and 44% of the groundwater use permits that the *Minas Gerais* Water Management Institute issued for withdrawal from the SFRB's tributaries in that state (Igam 2008).

Locals saw agriculture, not only the *Três Marias* Dam, as a cause of environmental problems (Clothes washer 2, PC, 16 May 2007, *Pirapora*-MG). Fields were located everywhere, including on the edge of the waterways' banks. The northern region of *Minas Gerais* produces fruits, soybeans and coffee. Inland zones had large sections of pine and eucalyptus to produce charcoal. The agricultural products of the *Pirapora* region included rice, beans, corn, banana, coffee, coconut, guava, orange, lemon, papaya, mango, passion fruit, tangerine, grape, and wood. *Pirapora* is a significant fruit producer in the state of *Minas Gerais* (Pirapora n.d., IBGE 2006b).

The Fishery. In late 1950s, fishing was one of the towns' major economic activities (IBGE 1959, IBGE 1960). Commonly caught species included *Surubim* (*Pseudoplatystoma coruscans*), *Dourado* (*Salminus brasiliensis*), *Curimatã* (*Prochilodus spp.*), *Piau* (*Leporinus spp.*) and *Traíras* (*Hoplias spp.*) (IBGE 1960, Alvim and Peret 2004, MMA and IBAMA 2004 for Scientific names). "[C]old-storage rooms in the town preserved the fish exported by railroad during the entire year" (IBGE 1960, 158). Despite the initial ecological impacts, such as from the *Três Marias* dam, urbanization, and deforestation, in the second half of the 1960s, fishing was still the major economic activity (Silva *et al.* 2000 citing SESI-MG 1969).[10] Women washing clothes and house wares on the *Rio da Unidade Nacional* "could see fish jumping" (Clothes washer 1, PC, 15 May 2007, *Pirapora* MG; Clothes washer 2, PC, 16 May 2007, *Pirapora*-MG). Fishermen could live only from fishing, and "they [fishermen] would be rich today if they had saved the money" (Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). The 158,447 kilos of fish caught in 1968 demonstrated the past intensity of fishing (Silva *et al.* 2000 citing SESI-MG 1969). *Dourado* (*Salminus brasiliensis*), *Surubim* (*Pseudoplatystoma coruscans*), and *Curimatã* (*Prochilodus spp.*) were the primary species caught (Silva *et al.* 2000 citing SESI-MG 1969, Alvim and Peret 2004). Around *Pirapora*, there were some 1,000 fishermen who worked the *São Francisco*, *Paracatu* and *Urucuia* Rivers. The fish also supplied cities such as *Belo Horizonte* and *Brasília* as well as *Pirapora* (Silva *et al.* 2000 citing SESI-MG 1969).

How have environmental changes affected fishing in the long term? Local residents and those who frequently visited the city noticed environmental changes regarding fishing during the last 30 years, such as a decrease in fish population (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). In the past, "in the waterfalls", during the reproductive cycle, "fish abounded" (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). Some reported changes in fish size. "The river was so rich that, even the fish's head

[10] Três Marias hydropower station went on line in 1962 (CEMIG 2002). Três Marias Dam is located about 130 km upstream from Pirapora.

used to be large. My ex-husband, a fisherman, used to exchange it for other products" (Clothes washer 2, PC, 16 May 2007, *Pirapora*-MG).

It is true that fish are still seen in the river during the *Piracema*, but not as many as in the past (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG). Fishermen catch, among other species, *Dourado* (*Salminus spp.*), *Curimatã* (*Prochilodus spp*), *Piau* (*Leporinus spp.*), *Curvina* (*Pachyurus spp.*), *Pirá* (*Conorhynchus conirostris*) and *Piranha* (*Serrasalmus spp.*) (Fishermen 1, PC, 18 May 2007, *Pirapora*-MG). But, *Surubim* (*Pseudoplatystoma spp.*), *Cari* (*Loricariidae*) and *Cari-preto* (*Pterygoplichthys etentaculatus*) were among the species difficult to catch in the river (Fishermen Association's staff and fisherman, PC, 15 May 2007, *Pirapora*-MG). It was possible to find non-native species in the SFR around *Pirapora*, such as *Tilápia* (*Oreochromis spp. and Tilapia sp.*), *Tucunaré* (*Cichla spp*) and *Pacu caranha* (*Piaractus mesopotamicus*) (Fishermen Association's staff and fisherman, PC, 15 May 2007, *Pirapora*-MG). These species have changed the natural dynamic of the local fish population. Fishermen say that, *Tucunaré* (*Cichla spp.*) is a nasty type of fish, which preys on other fish species. It is native from the Amazon Basin (World Fish Trust 2004). Upstream, in *Três Marias* reservoir, small-sized fish have declined significantly after the introduction of *Tucunaré* (*Cichla spp.*) (Sato and Godinho 2003).

Fishermen in *Pirapora* pursue many survival strategies. Today some fishermen need to find other jobs to help support their families (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG). Some believe that there are more fishermen too (Fishermen Association's staff and fishermen, PC, 15 May 2007, *Pirapora*-MG). That claim is difficult to assess because of the lack of precise statistics. In different regions of the SFR, fishermen are convinced that many people fish now, for lack of choice, while others are proud of their traditional way of life.

Environmental changes and governmental interventions have triggered new forms of resource management. Fishermen from *Buritizeiro* have established fishing rules.

Timed fishing for specific sites (*Cabeça do rego, Toma Banho, Pedra do Descanso-Barbaio*) came to exist on *Buritizeiro*'s side of the river in the zone of the waterfalls after the fishing closure of 1972. Fishermen have concluded that too many fishermen fishing at the same time when fish pass through the falls impairs fishing for everyone (Paula *et al.* 2006 citing Thé 2003, Thé and Nordi n.d.).[11]

Fishing in *Pirapora* is still an artisanal activity. Fishermen paddle small wooden boats, few fishermen use motorized canoes. The bicycle is the major form of transportation of fishermen on land. "Species-specific equipment such as cast nets and hook and line predominate and are directed towards the most valuable species. Multi-species gear gillnets are also used, although the catches take non-commercial species as well" (Sato and Godinho 2003:213). Nature dictates the work. It is a non-continuous activity, which takes time. Much of the catch is sold to intermediaries because fishermen do not have a way to preserve fish (e.g., freezers) and a market for salted fish does not exist anymore (Sato and Godinho 2003).

Federal and state monitoring systems are in effect to protect fishing resources. Nevertheless, they are unable to monitor the entire SFR, its tributaries and lagoons. Brazilian National Environment Institute – IBAMA and *Minas Gerais* Forest Institute – IEF issues regulations and monitors compliance, such as to avoid illegal fishing. In *Minas Gerais*, the state environmental police (*Polícia Militar Ambiental*) does this job. Governmental pro-environment actions mentioned by interviewees include closed fishing during *Piracema*. Nevertheless, fishermen still fish throughout such periods (AMDA 2007). In some cases, such as in the communal system developed on the *Buritizeiro* side of *Pirapora*'s waterfall, fishermen end up monitoring their peers.

[11] Thé and Nordi (n.d.) describe the Common Property System (CPS), which rights are inherited, bought, acquired when replacing fishermen who previously owned the rights, or consented when replacing someone else temporarily (Thé and Nordi n.d.).

Other Ecosystem Services. The river has supplied the city with fish, navigation, and hydropower, but also with water, stone, and aesthetical enjoyment. For example, the construction of the *Pirapora* dock started in 1940s. The river front construction, which aimed to protect the city against floods, used rock from the SFR's bed and *Pirapora*'s waterfall. CVSF concluded improvements of the port in 1957 (Serebrenick 1961). Before the upstream dam, floods occurred almost every year. The city was smaller, but flood waters inundated houses (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). Some people even had to flee for a while. The dam benefited the town by providing flood control (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG).

Lack of electrical power was a problem prior to the construction of *Três Marias*. In 1914, a wood-burning electricity generation station started to provide power to *Pirapora*. A private company, the *Companhia Indústria e Viação de Pirapora*, managed the electrical station (*Pirapora* n.d., Silva *et al.* 2000). In the 1940s, two private companies supplied the city mostly at night: thermoelectricity by *Companhia Indústria e Viação de Pirapora* and hydropower by another company using the waterfall for generation (Valverde 1944b, Zarur 1946). The local government took over the energy supply system in 1953. But in 1957, the federal water and electrical agency (*Divisão de Águas e Energia Elétrica*) linked to the Brazilian Agriculture Ministry started to manage the system. In the middle 1950s, CVSF provided diesel generators to supply *Pirapora*'s electric power replacing old units from the late 1940s (Silva *et al.* 2000). The diesel station completed in 1955, generated 1,050 kW (SUVALE 1968a).

In 1965, *Três Marias* and CEMIG, the electricity company for the state of *Minas Gerais*, started to supply electricity to *Pirapora* (*Pirapora* n.d.). In 1967, the older groups of diesel engines which existed in *Pirapora* were transferred to another municipality, *Unaí* (SUVALE 1968a). The *Três Marias* Dam brought the benefits of electricity and allowed industrial development. The hydropower generated replaced the supply from the

precarious system which had existed before. The construction of the electricity complex involved trade-offs. In addition, the electricity from *Três Marias* allowed the development of *Belo Horizonte* and other cities in the Southeast.

Interviewees who knew *Pirapora* before the operation of the dam acknowledged that navigation on the *São Francisco* always was a challenge. One crewman, who worked the run to *Juazeiro* from 1945 to 1977, commented that the river had been very shallow "50-60 cm deep" at the outset of his career. The river had high and low seasons, sand banks were present everywhere, and sailing sometimes required pushing and pulling the boat. "Sometimes the boat could not move for days" (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG).

After the construction of *Três Marias*, humans controlled the flow of the waters. The dam kept the waters high upstream as long as needed, and the waters could not run as freely as before. The 'domination' of the waters improved navigation. This was still the major focus of the dam project. Nevertheless, the focal point shifted from navigation to electrical power production. Then, "on some occasions, *Três Marias* kept the water and could not let the water go so as not to impair its control of energy generation" (steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). Others also stressed that *Três Marias*' priority shifted from river flow control to hydropower generation (Historian, PC, 17 May 2007, *Pirapora*-MG). For example, after a flood around 1980, which affected *Pirapora*, the city built a new protective dike (Silva *et al.* 2000). *Três Marias*'s priority was no longer flood control.

The 1997 Water Policy required management of water resources for multiple uses, but energy provision was the priority in river management (Navigation staff, PC, 17 May 2007, *Pirapora*-MG). Energy companies have managed Brazilian rivers for decades but other needs such as the maintenance of the ecosystem and the preservation of aquatic life, have not been their priority. Examples in recent years, excluding those of exceptional

rainfall and floods, were that locals saw a river with low water levels, "little water" as many describe it (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG). Interviewees relate a "low river", "empty", and "full of earth and sand." *Três Marias* Dam reduced the power of *São Francisco*'s water and the force of its current (Fishermen Association's staff and fisherman, PC, 15 May 2007, *Pirapora*-MG).

Water Supply. The first water distribution system of *Pirapora* started functioning in 1913 (*Pirapora* n.d., Silva *et al.* 2000). It was unable to supply every home in town and many persons collected water directly from the river. Years later, a private company, *Companhia Indústria e Viação de Pirapora* took charge and managed the system for a period of 25 years (Silva *et al.* 2000). Still it was not able to provide for the entire city. In the 1940s, the water supply for many came from the *São Francisco* River, with the water collected in the most polluted place, the riparian zone (Valverde 1944b, Duarte 1971). In the 1950s, Pierson noted that girls and women carried water home and filtered it with a cloth before using it. Some families living far away from the river used wells. The high city used wells and the lower city used water from the river (Pierson 1972, vol. 1).

In 1953, the local government returned to the management of the water treatment system. In 1955, the federal government's health agency, *Serviço de Saúde Pública* – SESP, implemented a partnership with the city to build a water treatment plant resulting in the *Serviço Autônomo de Água e Esgoto* – SAAE of *Pirapora* (*Pirapora* n.d., Silva *et al.* 2000).[12] In late 1950s, the system supplied only the urban zone (IBGE 1960). Water was withdrawn from the *São Francisco* River throughout a 300 meters long canal. The water treatment was of a basic, conventional type: water was mixed with aluminum sulfate to coagulate, flocculation, sedimentation-settling, filtration and disinfection with chloride (Silva *et al.* 2000 citing SESI-MG 1969).

[12] Serviço de Saúde Pública – SESP resulted from a Brazil-United States (Rockefeller Foundation) accord (Silva *et al.* 2000).

The mortality rate from 0 to 1 year of age before 1955 was a high 270 for each 1000 children. Lack of clean water and defective sanitation undoubtedly caused such high mortality. In 1966, the situation had already significantly improved to 84 for each 1000 children up to 1 year of age. Nevertheless, in 1966 only 38% of Pirapora had access to treated water. The other part of the community got water either directly from the river or indirectly from public water fountains (Silva *et al.* 2000 citing SESI-MG 1969).

Minas Gerais built a second water treatment plant in *Pirapora*. A state agency, *Companhia de Saneamento de Minas Gerais* – COPASA headed up the new station, located in the industrial district, to supply private industries (e.g., Antarctica beer factory). Nevertheless, in 1998, SAAE of *Pirapora* replaced COPASA in the management of this second station (*Pirapora* SAAE n.d.). Besides the industrial district, the second plant now provides water to other residential areas of the upper city. Water uptake takes place in the downtown and in the industrial district and still undergoes a conventional treatment (*Pirapora* SAAE 2006). SAAE now manages the two water treatment plants. Some 98.7% of *Pirapora*'s population is linked to the city's water system network (IBGE 2000b). As a result of the lack of sewage treatment in *Pirapora*, and neighboring cities and towns, samples of the water before treatment by the local water treatment plant (WTP) have showed signs of E-Coli (*Pirapora* SAAE 2006).

Três Marias maintains contact with the SAAE regarding water discharge so SAAE can supply the city. *Três Marias* needs to discharge at least 300m^3/s to avoid water shortage and other problems in *Pirapora*. In 2003, during the water and electricity shortage, the city saw algae blooms in the SFR and the water supplied had a bad taste. The 2003 drought increased the cost of treating water (Water Treatment Plant Staff, PC, 15 May 2007, *Pirapora*-MG).In 2004, the National Water Agency gave SAAE the right to withdraw a maximum amount of 232.5 L/s of water from the *São Francisco* River for a

period of twenty years [ANA Resolution# 370 of 2004].[13] SAAE can withdraw water and can also discharge treated sewage into the river (*Pirapora* SAAE n.d).

But, access to natural resources goes beyond the link of the household to the water treatment plant. Women wash clothes in the river because it is an enjoyable social activity, and to lower the water bill at home (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG). The city has worked to improve lower income people's water situation. In 2008, the city granted 15 cubic meters of water per month to poor consumers for the price of R$ 11.0134 a month, or about US$ 6 (*Pirapora* SAAE 2008). But women still meet in *Pirapora* next to the old bridge to wash clothes in the river.

Deforestation, Erosion, Siltation and Navigation. "The river channel is always on the *Buritizeiro* side of the river due to the waterfalls" (Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG).[14] Water carries sediments to the *Pirapora* side on the east bank, making a sand beach, which shows up when the river is low (IBGE 1960). Below the waterfalls, the river does not have a definite channel. "The *São Francisco* is always looking for its course" (navigation staff, PC, 17 May 2007, *Pirapora*-MG). In the process it carries away the riverbanks and riparian vegetation.

In addition to cattle, agriculture, deforestation, and mining activities along the SFR's tributaries, increases the amount of sediment carried into the streams of the region impairing navigation and other uses (IGAM 2008). Downstream from *Pirapora* to *Ibotirama*, a stretch of about 800 kms, navigation is now impossible, it would require dredging to free up passage (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG).The literature on water resources management and quality suggests that natural vegetation reduces riverbank erosion and removes contaminants that otherwise end up in the river (NALMS 2001).

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[13] The figure means 136 L/s to supply station one and 96.5 L/s to supply the water treatment facility number two [ANA Resolution# 370 of 2004].
[14] But, in 1879, Sampaio (2002) observed a canal used by unloaded canoes in *Pirapora*'s side of the river. During floods the area also allowed loaded canoes navigation.

Deforestation caused by cutting trees for steamboat fuel also contributed to the end of navigation from *Pirapora* to *Juazeiro-Petrolina*. It became more difficult to navigate in a shallower and silted river. Rocha (1983) had already noted in the 1930s that deforestation would be one of the problems faced along the *São Francisco* River. In the 1950s, in addition to steamboats, *Pirapora*'s steam railways used wood. The first diesel train only arrived in the region in 1957 (Silva *et al.* 2000, Engenheiros 1957). People also have collected wood for cooking around the town (Engenheiros 1957; Steamship staff 1, PC, 16 May 2007, *Pirapora*-MG). Deforestation due to mining activities, agriculture and cattle ranching further degraded the *Cerrado* vegetation of the upper-*São Francisco* River Region (Engenheiros 1957).

"Três Marias improved navigation ... but silting continued" (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). Sand banks had always existed, but today there are many more (Steamship staff 2, PC, 16 May 2007, *Pirapora*-MG). The end of navigation was also due to other causes. The streambed contains irregular rock formations (IBGE 1960, Rocha 1983).

River navigation decreased with roads, especially after Brazilian President Juscelino Kubitschek's government in the 1950s. Nevertheless, a paved road only reached *Pirapora* in the1970s.[15] The river travel underwent strong competition with other forms of transport, such as roads (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). Another factor, which lessened navigation in the middle-SFR, was the construction of the *Sobradinho* reservoir and dam in 1979 (CHESF n.d.b.). As related by a boat commander during my trip on the *Benjamin Guimarães* steamboat in 2007, it was difficult to navigate with the existing vessels on the lake, as there was too much wind, forming waves.

The *São Francisco* waterway from *Pirapora* to *Juazeiro-Petrolina* is under the subcontracted management of the *Companhia das Docas do Estado do Maranhão* -

[15] Paved roads resulted from PROVALE, created in1972. The construction of the road BR-365, funded by SUDENE, linking *Montes Claros-Pirapora-Patos de Minas – Uberlândia* was completed in 1974. The BR-496 opened in 1977 linking *Pirapora* to *Corinto* (Silva *et al.* 2000).

CODOMAR, a public-mixed company. The management of the waterway was charged with maintaining the river's navigability: adding signals to indicate the position of the main channel and dredging the stream (navigation staff, PC, 17 May 2007, *Pirapora*-MG). Both navigability and management present challenges.

Other Impaired River Uses: Cultural Values, Aesthetic Enjoyment, and Tourism. According to Silva (Silva *et al.* 2000), many watched with pleasure the landing and the departure of steamships. The *Benjamin Guimarães* is the last boat to still navigate the *Old Chico*.[16] In 1997, the *São Francisco* River Navigation Company – FRANAVE donated it to the local government for tourist purposes.

Minas Gerais is landlocked. Nonetheless, as stated by Eloy Ferreira Ramos, "Minas also has beach. Visit Pirapora" (Silva *et al.* 2000: 169). Many have done so... enjoying the beaches of the *São Francisco* River in *Pirapora*. As a result, the city's riverfront has changed. It now contains bars and restaurants (Gutberlet and Seixas 2003). Locals still enjoy the river and stop by to watch it (Clothes washer 1, PC, 15 May 2007, *Pirapora*-MG).

Environmental changes have negatively influenced tourism, with the resulting loss of income. The tourists do not come as before (Fisherman 2, PC, 18 May 2007, *Pirapora*-MG). In the early 1980s, on an average weekend about five thousand visitors arrived in town (Silva 1985). The rocks on the river are not clear anymore. Accumulation of sediment and growth of vegetation over them has impaired the environmental use of the stream. "Tourism is slow because of the sand" (Fisherman 2, PC, 18 May 2007, *Pirapora*-MG).

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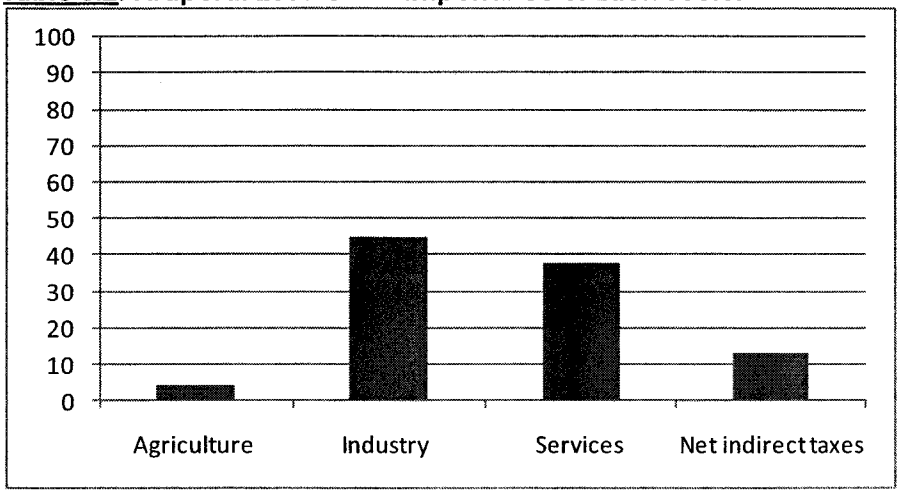
[16] James Rees Sons & Co. built the Benjamin Guimarães steamship, in the United States, in 1913. This steamship navigated several rivers: Mississippi, Amazon (for Amazon River Plate Co.), and the São Francisco. In the *São Francisco* River, the steamship received the name *Benjamin Guimarães* by the company *Júlio Mourão Guimarães* in 1920. The company *Navegação e Comércio do São Francisco*, owned by *Quintino Vargas*, bought this steamship in 1940. This company became part of *Companhia Indústria e Viação de Pirapora* in 1942. The *Benjamin Guimarães* became part of *Serviço da Navegação da Comissão do Vale do São Francisco* in 1955, and after that of FRANAVE. In 1997, FRANAVE donated it to the local government of Pirapora (Silva *et al.* 2000).

Many have noticed the change in the environment. They are averse to the growth of vegetation over the sediment above the river's rocks, in the last ten years. "In the past, we used to see river, stones, waterfalls... today we see vegetation" (NGO member, PC, 16 May 2007, *Pirapora*-MG). "It used to be clean rocks ...today they have dirt" (Clothes washer 2, PC, 16 May 2007, *Pirapora*-MG). In September 2007, the local government agency sought to address the problem. Its workers removed sediments from the river because it was impairing its uses (JMA 14 September 2007).

How Developed is Pirapora Today? In 2007, the federal census showed that 51,636 inhabitants lived in Pirapora (IBGE 2009a). In 2006, some of 45% of the city's income originated in the industrial sector, followed by 38 % from services (Table 6.2 below). Only 4% came from agriculture. The industrial development of this city is an exception in the valley. It includes textile, steelwork, dairy processing, and aluminum extraction factories (IGAM 2008). The creation of the industrial zone goes back to 1964 and resulted from industrial policies for the Northeast (Goldsmith 1991, *Pirapora* n.d., Silva *et al.* 2000). Until the 1960s, the city's industrial development was weak (Researcher, PC, 24 May 2007, *Belo Horizonte*-MG). In 1967 and 1970, meetings took place in *Pirapora* to attract more investment. At the time the zone hosted metal, textile, beer, and food factories (Silva *et al.* 2000).

As a commercial and service center for the sub-region, the municipality has five bank branches (IBGE 2009a). The businesses census reported that in 2005, the major employers of *Pirapora* were in manufacturing; followed by commerce; and government (IBGE 2008a). Indeed, some 35% of the workforce is occupied in industry especially textiles and chemicals; about 25% work in commerce and 14% have public jobs (IBGE 2006b). The transportation sector once employed almost 10% of the total population. Now it is much less than half that figure. Land transport has replaced water borne (IBGE 2006b).

Table 6.2. Pirapora: 2006 GDP - Importance of Each Sector[17]



Source of data: IBGE 2009a

The agriculture census of 2006 showed that 2,783 people worked on the land. Fishing is still a "rudimentary industry" (Historian, PC, 17 May 2007, *Pirapora*-MG). The census did not report the number of fishermen (IBGE 2008a). But, according to Dumont, *Pirapora* and *Buritizeiro* had 629 fishermen in 2006 (Dumont 2007).

The 2000 census showed that the income distribution in *Pirapora* was startling. Almost half (47%) of the total inhabitants ten-years and older do not have any monthly income (42% for Brazil). Some 22% receive less than 1 time the minimum salary (18% for Brazil).[18] Some 13% receive between 1 and 2 times the minimum salary (14% for Brazil). Some 11% receive between 2 and 5 times (15% for Brazil), and only 7 % receives above five times the minimum salary (11% for Brazil).

The Human Development Index for the municipality of *Pirapora* was 0.758 in 2000 (PNUD 2000a). The United Nation Development Program (PNUD) considers an average development level when the index is between 0.5 and 0.8 (PNUD 2000). *Pirapora*'s HDI

[17] GDP calculated using the value added method that is summing up all value added in different sectors and adding value added taxes (VATs).
[18] Minimum wage (*Salário Mínimo*) means the minimum income capable of satisfying the needs of workers and their families [1988 Constitution, Art.7]. In April 2008, a minimum salary corresponded to R$465 per month (Brazilian Real) about US$ 258.

has risen due to improvements in education (PNUD 2000). The 2000 Census showed that many of the city's residents have only four to seven schooling years (IBGE 2008a). The low per capita income pulls down the index (PNUD 2000a). Brazil's development index for 2000 was 0.766 (PNUD 2000). All the seven cities studied in the valley are below the national index figure (PNUD 2000a). In Brazil, for 48% of the municipalities in 2000, including *Pirapora*, their Human Development Indexes were between 0.650 and 0.800 (PNUD 2000).

Conclusions. The uses of the *São Francisco* River by *Pirapora*'s inhabitants have obviously changed. One can still enjoy a short tourist steamship trip on the river for US$ 17 ticket, but the average fishermen now barely survives from fishing. The residents still drink the river's water. The river remains a source for agriculture, commerce, and industry, and a sink for sewage. But, other uses surpass navigation and fishing activities which in the past were the major economic employment of the river. Different from the case of *Bom Jesus da Lapa* described in the next section, in *Pirapora*, local residents said the river is their soul, but they did not mention other religious aspects of the river. The stronger link between city's residents and the river seemed to be of a strong economic dependence.

The Faith in *Bom Jesus da Lapa*

> Penitents and supplicants, zealots, saints, and sinners come from hundreds of leagues- some to worship, some to give thanks, some from curiosity, and many to exploit. They come in canoes, sailboats and steamers – on foot, on mule – and cow-back, in bull carts and automobiles – rich and poor, high and low they come to this Brazilian Egypt to bespeak the favor of God in this holy limestone grotto (Bahia 1931, 16)

Introduction. In 1931 the text above described the pilgrimage to the city that Euclides da Cunha (2005) named the *Meca of the Sertão*'s people (*Meca dos Sertanejos*). How different was the trip almost eighty years later? The festivity is now the third largest religious event in Brazil measured by number of participants. My trip to *Bom*

Jesus da Lapa could not have happened in a better way to give me a real sense of what that place is really about. Two women from a Catholic Church group of my cousin's neighborhood organized a visit to the Sanctuary of *Bom Jesus da Lapa* (*Santuário de Bom Jesus da Lapa*). Three members of my family and I joined the group (Figure 6.4 below). After two days, the group returned and a cousin and I stayed for some days to continue my research.

It was quite a trip to the middle-SFR which two buses left my hometown in the early morning of August 2006. It was a very long ride. After almost a thirteen-hour trip, believing that we were very close to the city, we arrived at the worst part of the road, to be more precise, a dirt road. It was possible to see the dust arising from the dried land. The driver was off of the rutted main road, trying to find a better way and to escape the holes. The bus broke trees' branches of the barely green vegetation standing along the road.

In a straight line, the city is 509 kms away from the *Bahia* state capital (IBGE 1958). By road, the distance is of about 800 kms (Bom Jesus da Lapa 2009b). The city is situated in the middle-SFR, mostly on the east bank, with some territory on the other side of the river. *Bom Jesus da Lapa* officially became a city in 1923 (CODEVASF 2001). The municipality is 3,951 sq. kms large (IBGE 2009a). It is located at 435 meters above sea level (Barbosa 1995). Pirapora was 472 meters (Silva 1985). *Bom Jesus* is almost half way from *Pirapora* to *Juazeiro*.

The 1950 census showed that the city was home to 14,035 permanent residents (IBGE 1950+). The ones born in *Bom Jesus* are the *Lapenses* (IBGE 1958). In 1955, fishing and agriculture were the two major economic activities of the town (IBGE 1958). *Bom Jesus da Lapa* exported dried fish, leather and skins (IBGE 1958). The middle-SFR, including *Bom Jesus da Lapa* was an intensive fishing center and the existence of the

riparian lagoons was one of the reasons. Some of those water bodies formed in areas where the river's bed used to be (Pierson 1972, vol. 2).

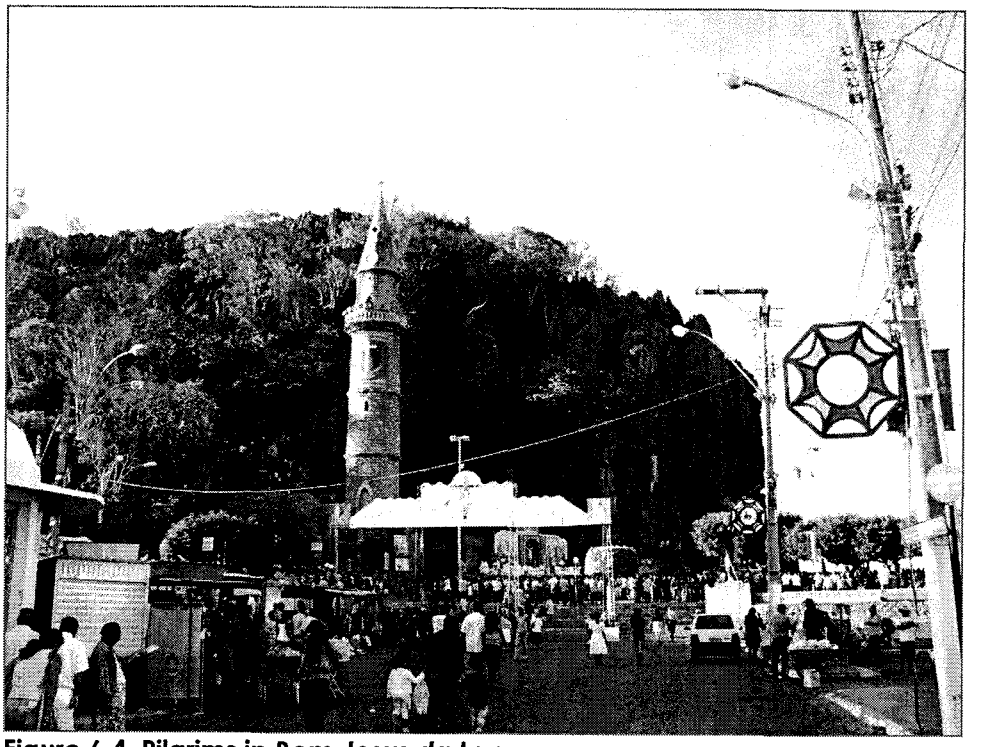


Figure 6.4. Pilgrims in *Bom Jesus da Lapa*
Source: Luci Nascimento 2006

As expected, the *Lapa* I saw more than a century latter was different from the village described by Viana in 1893 (1893). Today, many houses have more than one floor and are not only white-washed. Lapa includes dwelling of different colors. The city has more than eight streets and three squares. Nevertheless, something has not changed, "[t]he greatest celebrity of the village is [still] its church" (Viana 1893, 512).

Bom Jesus da Lapa is a sacred place. The city's history is the narrative of the church.[19] The caves of *Bom Jesus da Lapa* are a "natural beauty" sculpted by God (Mamala 2003). People have visited it for its religious reasons since the 17th century (CODEVASF 2001). The pilgrimage started after a citizen of Portugal had transformed a

[19] In 1989-1990, parts of *Bom Jesus da Lapa* formed two other municipalities, *Serra do Ramalho* and *Sítio do Mato* (Barbosa 1995).

cave into a home and a Catholic shrine. He fled from *Salvador da Bahia*, after a disagreement with a governor over payment for a painting job.[20] At that time, individuals on their way to the gold mines of *Minas Gerais* stopped at *Bom Jesus da Lapa* (Mamala 2003).

In 1943, during the months of *Bom Jesus da Lapa*'s festivities, May to August, about sixty thousand pilgrims visited the city (Valverde 1944). In 1966, that number was higher than 100,000 for the entire year (Gross 1971). Bom Jesus da Lapa has had other names: *Itaberaba*, *Morro*, *Lapa* and *Lapa do Bom Jesus* (Barbosa 1995). The city still fascinates thousands of pilgrims and tourists.[21] The festivities now extend from May to September during the dry season. The municipality receives more than one million people per year (Barbosa 1995). On August, 2006, during the mass, which took place in a crowded square in front of *Bom Jesus* cave, the Catholic priest read a list with the names of the places from where the pilgrims and tourists had come. It included nearby towns as well as cities from states outside of the Northeast of Brazil. Some priests, working in the sanctuary, are foreign nationals, showing the national and even international reach of *Bom Jesus*.

Some things will never change. It was still true that, "[m]any thousands of pilgrims travel long distances" each year to fulfill a promise made to *Bom Jesus da Lapa* (Gross 1971:131). Overcoming the challenges of traveling on dirt or badly paved roads by any means of transportation – foot, horse, cars, buses and truck – was part of the religious experience itself. Roads were more difficult during the wet season – October to April. The river has also been a way of transportation for people and goods to this religious place (Gross 1971).

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[20] Francisco de Mendonça Mar became the Catholic Church's Priest Francisco da Soledade in 1706 (Mamala 2003).

[21] According to Steil (2003), it is an impossible task to bind someone as a member of the two very similar groups of people who visit *Bom Jesus da Lapa*: pilgrims (*romeiros*) and tourists. They develop similar religious and touristy activities. Nonetheless, tourists describe themselves as spectator of pilgrims' expression of faith.

The waterway has transported gifts. People unable to attend the festivities have found interesting ways to send their offerings. In his 1867 trip, Burton saw a foot made of wax stuck in a sandbank along the SFR (Burton 1977). Figures prepared of such material represent the organ which received the grace of a cure. In 1956, in the first edition of his literary masterpiece, *João Guimarães Rosa* described one of those delivery alternatives, such as the one above, which also took place in the real world. Religious individuals upstream placed donations inside of an empty pumpkin like fruit, *cabaças* (*Cucurbita lagenaria*) and floated them on the river, hoping that the object would reach the mystical city (Rosa 1983). A local faithful individual would carry from the river to the grotto. The river played a critical mediating religious function. In our age of technology, new means help the faithful. It is possible to contact the sanctuary via the internet.[22]

The River Environment. Roles existed for both the waterway and God. The *São Francisco* could provide the food for everyday survival and *Bom Jesus da Lapa* would protect all (SERFHAU and SUDENE 1972). *Bom Jesus da Lapa*'s weather is hot and dry (Barbosa 1995). It is located entirely in the valley jurisdiction and in the semi-arid region. The average temperature is 91° F (Barbosa 1995). The city is situated in the middle-SFR, about 750 kms from *Juazeiro* (Zarur 1946). It is part of the *Caatinga* and Cerrado biomes.

In 1944, Valverde noticed that the houses of the town were located far from the river and closer to the hill. The homes turned their back to the *São Francisco* River and its front to *Bom Jesus da Lapa*'s sanctuary. Houses were absent in the port zone (Valverde 1944). In the distant past, the water used to come close to the mountain's base, but now this happens only during floods when the *São Francisco* comes through a river's channel (Mamala 2003). In 1867, Burton (1977) saw that area near by the mountain as a refuge port. In 1879, Sampaio (2002) described it as a bay, a lake of calm waters (*ipueira*),

[22] *Bom Jesus da Lapa* Sanctuary: http://www.bomjesusdalapa.org.br/ accessed on 16 October 2009.

formed between the river and the sacred mountain. The area also hosted commerce (Burton 1977).

The existence of flooding explains the distance of the houses from the river noticed by Valverde in the 1940s (1944b). Sampaio (2002) previously observed this pattern in different stretches of the river in 1879. CVSF's infrastructure improvement in 1960s, such as the construction of the dock, allowed other riverfront construction (Mamala 2003, Serebrenick 1961). Now, houses in that area overlook the river. But, flooding still occurs. The local residents remember the hardships of the one in 1979. The river's channel often changed in relation to the river margins (group of fishermen and fisherwoman, interview, 22 Aug 2006, *Bom Jesus da Lapa*-BA, Irrigation and agriculture-CBHSF, PC, 23 Aug 2006, *Bom Jesus da Lapa*-BA).

The SF River is understood locally as the father and mother of many. It is a means of survival (Irrigation and Agriculture-CBHSF, PC, 23 Aug 2006, *Bom Jesus da Lapa*-BA). An interviewee claimed that the stream is the "rudder of the population" (Market oriented small farmer, PC, 20 Aug 2006, *Bom Jesus da Lapa*-BA). Nevertheless, anyone who has experienced the feelings of being in this place can guess that the captain of the ship is *Bom Jesus*. In town, nothing is bigger and represents more than *Bom Jesus*. How about the river? It is a God's blessing (Ex-clothes washer, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA). It "is our lifesaver... produces from fish to everything" (Market oriented small farmer, PC, 20 Aug 2006, *Bom Jesus da Lapa*-BA). Indeed, the major uses of the river in *Bom Jesus da Lapa* have been for fishing, agriculture, water supply, transportation and religious purposes, such as boat processions. Still, water scarcity and quality affect the population, agriculture and animal raising in the municipality (IBGE 2005b).

Causes of Environmental Degradation. The large influx of visitors has an intense impact upon the local environment. Pilgrims have used the waterway to bathe, defecate, and to collect drinking and cooking water (Gross 1971, Oliveira 2008). They

also have used other resources of the river system, such as fish. The presence of tourists is a problem for environmental protection (state agency staff, PC, 21 Aug 2006, *Bom Jesus da Lapa*-BA). In 1951, Herman Baity, an American sanitary engineer wrote that, "congregation [of visitors] at *Lapa* constitutes one of the world's greatest spectacles of religious fervor, mass psychology, and insanitation" (Baity 1951, 43). In 1958, a news reporter noticed the same lack of hygiene. Pigs stirred up the refuse left in the streets (Marques 1958a). In 1960s, "[o]verflowing drains left a foul odor in many parts of the town" (Gross 1971).

The municipality has a sewage treatment station. It collects, filters and places the sewage in sedimentation lagoons (State agency staff, PC, 21 Aug 2006, *Bom Jesus da Lapa*). But the system cannot meet the existing demand and not every pipe is connected to it. According to the 2000 census, only 9.4% of homes in the urban area are linked to the city's sewage network or have an improved septic system (IBGE 2000b).The federal government has provided a grant through the *São Francisco* River Revitalization program for a city-CODEVASF partnership to upgrade the city's sanitation structure, increasing collection and improving the methods that will include secondary treatment (*Bom Jesus da Lapa* 2009h). The National Water Agency has granted the city through SAAE the right to dispose treated domestic sewage on an average of 143.58 L/s until December 2020 [ANA Resolution # 493 of 2007, Art. 1]. But raw sewage still enters the Velho Chico. In addition, not all the impacts upon the local environment come from sewage pipes.

Visitors have increased the amount of trash including plastic bags, bottles, cans and papers left on the river's bank. The tourists were not the only ones to blame. The local government is in charge of solid waste but a proper disposal program did not exist (*Bom Jesus da Lapa*-SAAE 2009c, *Bahia*-CRA 2004). In early 1950s, local government used carts to collect garbage and refuse and to dispose of it in undeveloped zones (Baity

1951). In early 1970s, only 20% of the resident population had access to this service (SERFHAU and SUDENE 1972). The lack of a proper form of waste management is still an issue in the city (Bahia-CRA 2004, IBGE 2005). Only 64% of the homes in town have access to garbage collection (IBGE 2009b). The city's population also used the river to dump trash (Agência Brasil 2008) (ex-clothes washer, PC, 22 Aug 2006, *Bom Jesus da Lapa*-Bahia).

Agriculture and Other Non-point Source of Pollution. Besides dry-land agriculture in inland areas, the locals practiced subsistence agriculture along the rivers' banks and islands (Valverde 1944b, SERFHAU and SUDENE 1972). Sweet-potato, rice, beans, sugar-cane and corn figured among the most important agricultural items. But, the agricultural products (e.g., manioc, rice, beans, tobacco and fruits) sold in *Bom Jesus da Lapa*'s public market came from the *Corrente* River Basin, a *São Francisco* River tributary on the left bank (IBGE 1960). Agricultural methods in the municipality have certainly changed as in many other places in the valley. Irrigation in *Bom Jesus da Lapa* on the west side of the basin still uses the water of that *Velho Chico*'s inlet. Irrigation projects in the region produce many things, such as beans and bananas (Market oriented small farmer, PC, 20 Aug 2006, *Bom Jesus da Lapa*-BA). The expansion of agricultural activity in the municipality, in addition to deforestation and silting, were also the cause of water and soil pollution (IBGE 2005b).

The Fishery. Several lagoons used to exist in the area of *Bom Jesus*. The river was full of fish especially during the period of low water (Irrigation and Agriculture-CBHSF, PC, 23 Aug 2006, *Bom Jesus da Lapa*-BA). *Curimatã*, *Surubim*, *Piau*, *Traíra* (*Hoplias malabaricus*), *Bagre* (*Rhamdia quelen*) and *Piranha* were the key fish species (IBGE 1958). Fishing took place both in the lagoons and in the river's main channel.

The middle-SFR including *Bom Jesus da Lapa* was an intensive fishing center using artisanal methods. In 1968, fishermen caught 215 tons, in 1969 385 tons and in 1970 the

catch amounted to 366 tons (SERFHAU and SUDENE 1972). The numbers reveal the importance of the activity for the town and region. Fishing was economically vital to low-income people. *Surubim, Curimatã, Piau* were still important species. Port and public market's areas in addition to sellers walking all over town marketed the product. The fish were mostly consumed in the municipality, though some was exported to the south of *Bahia* by road, especially to *Jequié* (SERFHAU and SUDENE 1972).

Três Marias affected the river environment similarly in *Pirapora* and in *Bom Jesus da Lapa*. The lack of floods has reduced fish and the number of fishing boats (Mamala 2003). The same federal legislation regulates fishing along the SFR. Professional fishermen need a permit and cannot fish during the reproductive period. Professional fishermen also receive a subsidy from the federal government to be able to survive during the non-fishing season. Other causes of environmental degradation for aquatic species noticed by local governmental staff were water pollution due to sewage, destruction of riparian zones and predatory fishing (IBGE 2005b).

Other Ecosystem Services. The SF River has provided more than water and food for the *Lapenses* and the others who have stayed in the city. For example, clay for houses came from the river (IBGE 1960).

Electric power lighted up *Bom Jesus da Lapa* church for the first time in 1935 (Mamala 2003; Pierson 1972, vol. 3). The energy did not come from the river. By late 1950s, the electrical system was very precarious and supplied the city only from 19:00 to 23:00 (IBGE 1960). The system improved in 1963. President *João Goulart* inaugurated the *Usina Hidroelétrica de Correntina* and the transmission line from the station in the city of same name to *Bom Jesus da Lapa* (SUVALE 1968a, Novaes 1989). The station used the hydropower of a *Velho Chico*'s tributary.

In early 1970s, only 18% of the population had access to electric power. The state electric power distribution company, COELBA, provided energy twenty-four hours a day

generated by the *Correntina* River (SERFHAU and SUDENE 1972). Today, the national energy system is interconnected.

Water Supply. Valverde (1944b) described the simplicity of *Lapa*'s water system in the 1940s. Suppliers sold barrels of water transported by donkeys and ox carts to homes (Valverde 1944b, Baity 1951). Local people also carried water in cans, pumpkin-like fruits and clay reservoirs, on their head or in their hands (Baity 1951; Pierson 1972, vol. 1; Gautherot and Frota 1995). In a 1951 report, Baity strongly recommended to the Brazilian health agency the construction of water treatment and sewage collection plants for the town because of the number of visitors. The treatment of sewage was deemed to be un-necessary due to the dilution possibilities of the river at that time (Baity 1951). But by the late 1950s, *Bom Jesus da Lapa* still did not have water and sewage treatment systems (IBGE 1960). As an interviewee remembered, water was still carried on the back of donkeys (market oriented small farmer, PC, 20 Aug 2006, *Bom Jesus da Lapa*-BA).

The water treatment plant of *Bom Jesus da Lapa* exists since 1966 (*Bom Jesus da Lapa*-SAAE 2009a; Water treatment plant's staff, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA). In its initial years, the service distributed water to public fountains located on the city's main plaza. The system supplied water to ten public fountains. In the early 1970s, only 16% of the population had access to water at home (SERFHAU and SUDENE 1972). A partnership between the local government and the Federal Health Foundation managed the water treatment station until 1998. The municipal agency, the SAAE has managed the system since the late 1990s (*Bom Jesus da Lapa*-SAAE 2009a). SAAE of *Bom Jesus da Lapa* is in charge of both water and sewage systems (*Bom Jesus da Lapa*-SAAE 2009c).

The WTP of *Bom Jesus da Lapa* works nonstop. The pumper is located on a float in the river (*Bom Jesus da Lapa*-SAAE 2009f). The *Velho Chico* is the source for the city and the water undergoes a conventional treatment (flocculation, disinfection, filtration,

addition of fluoride) (*Bom Jesus da Lapa*-SAAE 2009g; Water treatment plant's staff, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA). According to an interviewee, today the city has a good WTP (State Agency staff, PC, 21 Aug 2006, *Bom Jesus da Lapa*-BA). SAAE treats the water. It has become more important now, given the observed deteriorating condition of the river's water quality (Ex-clothes washer, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA).

In 2005 the National Water Agency granted the SAAE of *Bom Jesus da Lapa* the right to withdraw daily, for a twenty-year period, an average of 114.72 L/s of water from the *São Francisco* River (*Bom Jesus da Lapa*-SAAE 2009e, ANA Resolution # 239 of 2005, Art. 1). In the urban area, 98.6% of the homes are linked to the city's water supply system (IBGE 2000b).

Deforestation, Erosion, Siltation and Navigation. In the 1940s, few trees existed in the city itself (Gautherot and Frota 1995), though a rich forest was still present in nearby districts (IBGE 1958). It provided habitat for numerous species of wild animals (IBGE 1958). Steamers and domestic use devastated riparian forests (Engenheiros e Economistas 1957). The destruction of habitat and overhunting eliminated several species such as alligators, lizards, wild cats such as *gato-maracajá* (*Leopardus wiedii*) and wild pigs namely *porco-queixada* (*Tayassu pecari*) (SERFHAU and SUDENE 1972).

In the late 1950s, truck transport was not economically feasible for many products (IBGE 1960). The *São Francisco* was the most important transportation axis to *Bom Jesus da Lapa* (IBGE 1960). But, the boats making stops in the city were often already full, and the loading of cargo into boats was very difficult (IBGE 1960). River navigation was also not easy, and boats ran aground on sandbanks, as an interviewee described, "The steamboat used to run aground and did not leave" (boat man, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA).

Another challenge was that the river changed its main channel often, especially due to the erosion of its margins (Pierson 1972, vol.1). Erosion of the river banks is a natural

phenomenon due to the sandy soil. But, anthropogenic factors have aggravated erosion, for example the erosion caused by the degradation of riparian vegetation. The rainy season in the upper reaches helped navigation in the middle-SFR (Pierson 1972, vol.1). Três Marias brought the hope navigation would be improved (Gross 1971). Only the hope! Small and medium-sized steamers transported passengers and cargo. By the early 1970s, *Bom Jesus da Lapa*'s links even with its own districts took place by river. This form of transportation gave way to road transport (SERFHAU and SUDENE 1972).

In 1986, a researcher known as the "elder of the river" ("*o velho do rio*") due to his knowledge about the waterway traveled to various cities of the middle-SFR. He reported that in *Bom Jesus da Lapa* the river was lower than ever before for that time of the year, June. More than one-third of the river's bed was uncovered, impairing navigation and forcing boats to dock far from the shore (Araújo 2003). *Bahia*'s governor, Nilo Coelho, built the bridge over the *National Unity River* in 1991-92. The bridge and paved roads reduced the need for navigation (Mamala 2003).

Other Impaired River Uses: Cultural Values, Aesthetical Enjoyment and Tourism. The reduction in the number of boats caused by the building of the bridge, the condition of the river and the reduced importance of this way of transportation also reduced the use of the river for religious purposes. It decreased participation in the fluvial pilgrimage on the *Bom Jesus dos Navegantes*' Day, on the last Sunday of January (Mamala 2003). Besides Catholic influences, other religious and legendary symbols are associated with the river, such as the black man of the waters (*Negro d'Água*). As stated by an interviewee: "I have not seen a *Negro d'Água*...But I also believe that it exists, the elderly say so" (boatman, PC, 22 Aug 2006, *Bom Jesus da Lapa*-BA). Local people made no mention regarding the effects of environmental changes upon those figures.

How Developed is *Bom Jesus da Lapa* Today? In 2007, 62,199 people inhabited *Bom Jesus* (IBGE 2009a). Among the interviewees, I found those who had been born in

Lapa, others who have arrived after the resettlement scheme connected to *Sobradinho* Dam, and others who came to the city for religious and other reasons (Group of fishermen and fisherwomen, PC-group interview, 22 Aug 2006, *Bom Jesus da Lapa*-BA).

Bom Jesus has a Human Development index of 0.654, below the national average (0.766) (PNUD 2000a). The low income of the municipality contributes to the low index level.

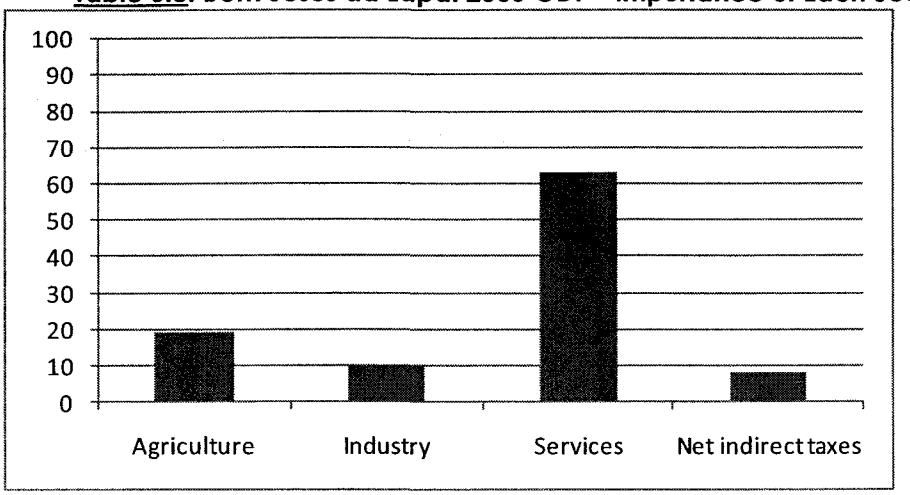
The city has been the commercial and service center for the broader region. In 1971, it had a federal and a state owned banks (SERFHAU and SUDENE 1972). In 2006, during my fieldtrip, different from many municipalities of the countryside, I saw two governmental and one privately owned commercial financial institution. The development bank for the Northeast, *Banco do Nordeste do Brasil* has one branch in town.

The pilgrimage and tourist activities are important direct and indirect sources of employment and income for the town. The activity brings significant temporary employment. *Bom Jesus da Lapa* inhabitants informally rent their houses to visitors (SERFHAU and SUDENE 1972). Indeed, in the 1970s, Gross (1971) found 45 registered "hotels" and countless other types of lodging.

Gross (1971) noted various tourism related retail outlets, such as religious souvenir shops. Most of the products sold locally were made in *São Paulo* and other places in the South (Gross 1971). In August 2007, in a more globalized world, I saw products "Made in China," commonly found in the informal retail sector of large cities such as *Salvador*.

The Gross Domestic Product of *Bom Jesus da Lapa* shows the importance of services for the local economy. It accounts for 63% of the total income generated (Table 6.3 below). The category includes the activities related to the tourism industry. Commerce employs 37% and public jobs are 34% of the workforce (IBGE 2006b).

Table 6.3. Bom Jesus da Lapa: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

In early 1972, animal herding was still of economic significance. A high animal density existed with cattle occupying the first rank, followed by goats and sheep (SERFHAU and SUDENE 1972). In 2007 the herd of cattle included 56,171 animals (IBGE 2009a). In 1970, agriculture and livestock accounted for 54.8% of the product created in the municipality. Beans and fava beans, and raw materials such as cotton, sugar-cane and castor-oil seeds were in the top of the list. Gathering of products such as wood and *carnauba* wax accounted for 25.7% (SERFHAU and SUDENE 1972). Agriculture accounts now for a little less than 20% of the total output (IBGE 2009a). Fruits are an important item in that category. In 2008, the municipality produced 150 thousand metric tons of bananas and 17 thousand metric tons of papayas.[23] Bom Jesus da Lapa produced 15 thousand metric tons of cassava.

In early 1970s, fishing accounted for 9.1% of output. It was by then economically important only for a small part of the population (SERFHAU and SUDENE 1972). According to fishermen and fisherwomen of *Lapa*, in the past a lot of fish existed, but the price paid was very low. Today the inverse situation exists (Group of fishermen and fisherwomen, PC-group interview, 22 Aug 2006, *Bom Jesus da Lapa*-BA).

[23] In *Bom Jesus da Lapa*, the production of bananas takes place in areas such as in the irrigation projects of *Formoso*. It includes plots of lands under the model of familiar agriculture (Pacheco 2007, Bahia 2009).

In 1972, only one large industry existed in *Bom Jesus*, MANGAL S/A. It processed cotton and feathers. Other smaller factories processed coffee, corn and wood (SERFHAU and SUDENE 1972). In 2006, industries accounted for 10% of the income produced in town (IBGE 2009a). It employed less than 2.5% of the workforce mainly in food-beverage and mineral sectors (IBGE 2006b).

Conclusions. Religious tourism continues to be the most important socio-economic activity and source of revenue for *Bom Jesus da Lapa*. The *São Francisco* River does not bring as many pilgrims, tourists and donations as in the past. But, the waterway plays a vital role providing ecosystem services that make possible the existence of such a popular agglomeration. The river is a source of resources and a sink of waste. *Lapa* is finding a new source of income. It is now the capital of bananas.

The Twin-Cities: Juazeiro and Petrolina

As the song below illustrates, it is impossible to speak about one of the two cities in isolation. But, without doubt, everyone has a preference.

> Beauty was born on the margins of the *São Francisco*
> That beauty preserved Nature
> Jesus blessed the beauty with his divine hands
> To avoid my own death of homesickness, I will go back to *Petrolina*
>
> Another city exists on the other side of the river
> I used to visit it every day during my youth
> Full of happiness as I used to cross the bridge
> When I used to arrive in *Juazeiro*, *Juazeiro* of *Bahia*
>
> Today I remember when I was a child
> The boats' prow heads and the whistle of the trains were strange
> But, it was beautiful to see the bridge opening
> And the steamer gliding over it
>
> *Petrolina*, *Juazeiro*, *Juazeiro*, *Petrolina*
> Both are beautiful places
> I like *Juazeiro* and I adore *Petrolina*
>
> Song: *Petrolina Juazeiro*,
> By: *Jorge de Altinho*

Introduction: Juazeiro and Petrolina that I saw. In July 2006, I left *Salvador* for *Juazeiro*, an eight-hour trip on an express bus with few stops along the way. Through the windows, I observed the changing landscape from the heavily populated metropolitan area of *Salvador*, to the green sugar-cane fields of Bahian *Reconcavo*, to cattle pastures, and then to the dried vegetation of the semi-arid zone.[24] The scenery included the rusted tracks of the once-famous railway linking *Salvador* to the *Sertão* of *Bahia*.

I have visited *Juazeiro* and consequently *Petrolina* four times: on two scoping trips (July 2002 and August 2004) and during fieldwork in July-August 2006 and June 2007. In a couple years, I observed that the downtown area had changed markedly, especially the back streets. New stores took over old houses and commercial shops. The main riverfront street also had a new structure under construction, on the plaza where the old steamship, *Saldanha Marinho*, is the cultural attraction (Figure 6.5 below).

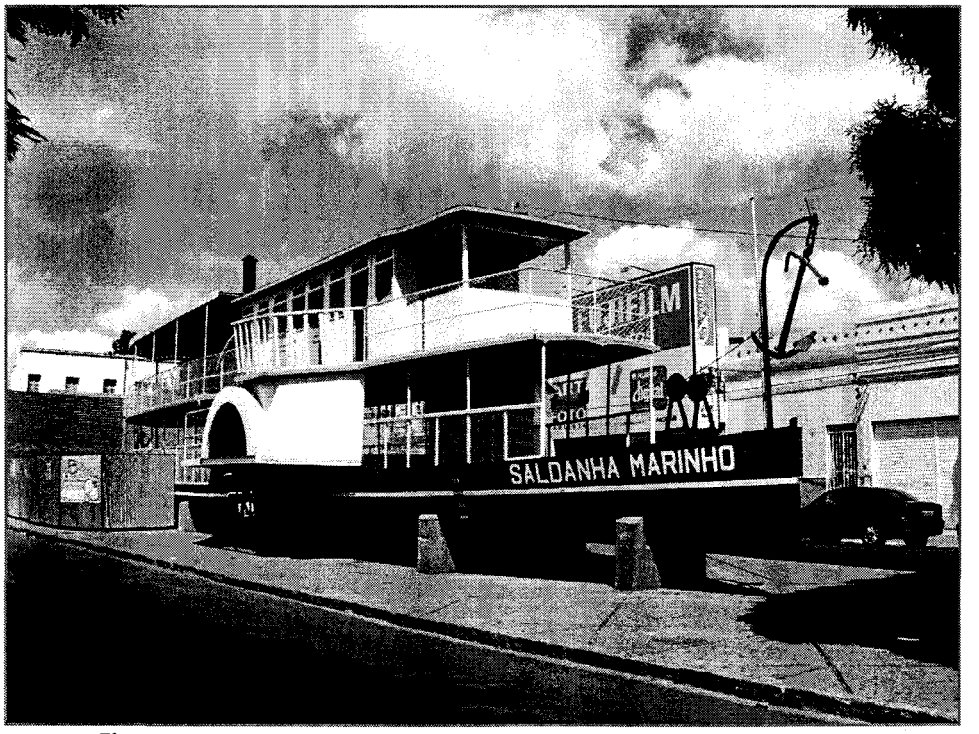


Figure 6.5. *Saldanha Marinho*
Source: Lucigleide Nascimento 2006

[24] *Reconcavo* is a humid transition zone between the Atlantic coast and inland regions of the coastal bay where *Salvador da Bahia* is located.

Petrolina did not change as much in the last couple years. "*Petrolina* is more developed than *Juazeiro*," asserted my travel companion. Based solely upon urban development, I did tend to agree. Visually, it has more high buildings and better roads than *Juazeiro*. The differences between the twin-cities are noticeable, as is the link between them: the river. Especially in the morning and late afternoon despite the existence of a bridge, ferryboats come and go, bringing thousands from one city to the other.

I wondered especially in the case of *Juazeiro*, how could a place have changed in such a short period? What were the transformations the boat captains, fishermen and other members of the elderly population have seen in the last sixty years? I used the existing literature and the experiences of the locals to gain ideas of what has changed. My own observations complemented the sea of information these two other sources provided.

Juazeiro: "Princess of the Bahian Sertão." In 1867, Burton (1977) described *Juazeiro* as a long row of riverfront houses. The waterway there was 800 meters wide and ran in a straight line from west to east with few trees on its beach (Burton 1977). In 1879, Teodoro Sampaio noted that *Juazeiro* was already a rich city, different from neighboring towns (IBGE 1957). In 1872 and 1892 the population was respectively of 7,863 and 10,567 (Vianna 1893). At the end of the nineteenth century, *Juazeiro* had "twenty streets arranged in a continuous line, parallel with the river, and bordered with elegant houses, plastered or painted in different colors" (Vianna 1893, 467). Its beauty and development gave to the municipality different names: the "*Princess of the Bahian Sertão*" and the "*Shop of the São Francisco Sertão*" ("*Empório do Sertão do São Francisco*") (Bahia Illustrada 1919, n.p.; Sampaio 2002, 102). Commercially, *Juazeiro* then already had influenced upstream towns namely, *Januária* at 1054 kms away, and downstream places such as *Cabrobó* 203 kms distant. The famous place impacted other states such as *Piauí*

and *Goiás*, and the city on the opposite bank of the river, *Petrolina*. *Juazeiro* hosted theater, boat fleets, and a deep large port (Sampaio 2002).

Similar to *Pirapora*, *Juazeiro* and its port have been a major center for the region. It was the site for the commerce of various products such as leather and skins, rubber made of *maniçoba* and *mangaba*, *carnaúba* wax, fish and dried meat, sugar-cane bars/cakes, and the high quality alcoholic drinks (*aguardente*) produced in *Januária*, *Minas Gerais* (Bahia Illustrada 1919, n.p.).[25] Even imports from Europe reached the city, initially carried by mules from *Salvador* (Sampaio 2002). Large commercial houses in the capital city, Salvador distributed their imported wares throughout the Bahian interior by mule trains. In *Juazeiro*, the market took place on the riverside (Bahia Illustrada 1919, n.p.).

Juazeiro became a city in 1878 (IBGE 1958b). Its location was fundamental. It was the crossing point of all sorts of communication. The river was essential. As noted by an interviewee, before electricity navigation was the major river use (Civil society representative-CBHSF, PC, 2 Aug 2006, Juazeiro-BA). In fact, navigation and the railroad at the end of the XIX century induced the growth of the city. It used to take about fifteen days to go from *Juazeiro* to *Salvador*, or vice verse, by mule pack-train (Sampaio 2002: 104; Bahia 1931). But, by train the journey was shortened to only about 54 hours (Alcock 1907). Again, similar to Pirapora, the intermodal system worked the best. Privately owned large sailboats supplemented by oarsmen complemented steamboat transportation. On land, the *Estrada de Ferro Bahia – São Francisco* Railroad connected *Juazeiro* to *Salvador* in 1894 (Bahia Illustrada Apr 1919, n.p., IBGE 1957). In 1919, that trip took two days. The train went all the way to the river's edge (Bahia Illustrada 1919).

As in the medium-SFR, navigation was a challenge. Sandbanks impaired steamboat navigation on the route *Juazeiro-Petrolina* to *Pirapora* during lower water

[25] *Brejo do Salgado*, known as *Salgado*, is *Januária* (Sampaio 2002).

season (IBGE 1960b). Riparian cities depended on small sailboats for regular commerce because they had fewer navigation problems year-round (IBGE 1960b). Unpaved roads were a poor access medium (1960b).

In the early 1940s, the *Juazeiro* city area did not produce many agricultural items, *Salitre*, a SFR sub-basin did and supplied the city, especially with onions and grapes (Duarte 1971). *Juazeiro* was a primarily commercial and central city providing services to other towns. *Juazeiro* had six hotels besides boarding houses (Duarte 1971). The riparian market was busy during different days of week (Azevedo 1946).

In the late 1950s, *Juazeiro* was still the most important commercial city in the lower-middle (IBGE 1960b). Its industries processed leather and fibers, produced shoes and textile, and manufactured cans (Engenheiros 1957, Silva 1985). The city was the business square, in the local's traditional language, "*a praça*" (IBGE 1960b). It redistributed through fluvial commerce the products which arrived by road and railroad from *Salvador*, manufactured products such as textiles, ironwork from *Minas Gerais* and salt from *Rio Grande do Norte* (Azevedo 1946, IBGE 1960b). In the1960s, the roads gave more importance to the city (Carmo 2006c). They also led to the decline of railroad transportation. The broken-down historic train station built by the British *Bahia and São Francisco Co.* today is home to drug addicts and thieves.

Petrolina: "Princess of the Pernambucan Sertão." Both cities stand out as princesses in the general region. *Juazeiro* in *Bahia* and *Petrolina* in *Pernambuco* were also known as the locations for crossing the *São Francisco* River, they were "*Juazeiro* crossing site"(IBGE 1960b, 358). In 1867, a church, half-dozen houses and few tents comprised *Petrolina* (Burton 1977). In 1879, Sampaio described Petrolina as an "insignificant village" with ugly houses along narrow streets, a very modest church, few inhabitants, and a low level of commerce (Sampaio 2002).

Juazeiro influenced the growth of *Petrolina*. A ferry linked the two places (Burton 1977). In 1895 it became a city, but was still dependent on *Juazeiro*'s influence. A few strong patriarchal families influenced politics and the economy based upon cattle ranching with little industry (Chilcote 1990).

Around 1920, the *maniçoba* (*Manihot caerulescens*) rubber industry changed the local economy increasing commerce along with cotton production and cattle raising (Azevedo 1946, Chilcote 1990). Incipient industrial development included tobacco factories, a cotton mill, a vinegar and three soap factories. By the1930s, *Petrolina* became a "center of intellectual life", hosted primary and secondary schools and civic and social organizations (Chilcote 1990). In the early 1940s, it was more a residential city and its commerce was weaker than in *Juazeiro* (Duarte 1971). Indeed, the public market was only busy on Mondays, and was smaller than that of its twin city. Most products came from other places except fiber and leather item such as hats and shoes (Azevedo 1946). The army built the port of *Petrolina*, which started operating in 1944 (CONDEPE 1987).

But *Petrolina* still benefited from the commerce of *Juazeiro* and the river system, and later on from railroad and road development (IBGE 1960b). Nonetheless, both cities shared the same challenges regarding the seasonal difficulty of navigation on the waterway. By the late 1950s, a 204 kms railroad linked the city of *Paulistana* in *Piauí* to *Petrolina* (IBGE 1960b, Zarur 1946). *Petrolina* distributed the products that arrived in *Juazeiro* to other regions (IBGE 1960b). The population crossed from *Juazeiro* to *Petrolina* by small boats called *paquetes* (packet-boats), boats equipped with sails (Vianna 1893; Bahia Illustrada 1919). This type of boat existed until the introduction of the ferry powered

by diesel used by many today to cross the river (Clothes washer #2, PC, 1 Aug 2006, *Juazeiro*-BA).[26]

In addition, other boats supplied the city and the region with countless items: from textile to iron products such as nails (mechanical/boat driver, PC, 02 Aug 2006, *Juazeiro*-BA). Three major steamship companies co-existed in the middle and lower-middle-SFR. But, when vehicles arrived to cross the river before the construction of the bridge, only one transport existed: the *Topázio*. It was an arduous task. As an interviewee described, the work used to start 5:00 a.m. Workers removed the products from the truck and were placed in the *Topázio*, and crossed to the other side of the river, where the products were to be removed. The truck crossed the river on board the *Topázio* and workers reloaded its cargo in the other side of the river. Only three vehicles used to be able to cross the river per day (Mechanical/boat driver, PC, 02 Aug, 2006, *Juazeiro*-BA). The region included many navigation transportation workers (Zarur 1946, mechanic/boat driver, PC, 02 Aug, 2006, *Juazeiro*-BA).

Juazeiro and Petrolina: Friendship and Rivalry.[27] *Juazeiro* is located on the east and *Petrolina* on the west bank of the lower-middle-SFR (Figure 6.6 below). In the 1950, the population of Juazeiro was 19,820 and 34,416 including its districts. *Petrolina* alone had about 6,500 inhabitants (Baity 1951) and including its districts some 27,330 (Censo 1950+). *Juazeiro* is 6,390 sq. kms large. *Petrolina* is smaller than its twin city being 4,559 sq. kms large (IBGE 2009a). *Petrolina* is 637 km away in a straight line and 743 by road from *Pernambuco*'s capital, *Recife*. *Juazeiro* is closer than that to the state capital of *Bahia*. It is located 430 kms away from *Salvador* in straight line and 531 km away by road (IBGE 1958b).

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[26] Propeller-driven barges replaced wood-burning and steam-driven paddle wheels in late 1960s (Chilcote 1990).

[27] The *São Francisco* Economic Development Commission – CODESF is another example of the friendship and rivalry between the twin cities. CODESF started working in 1964 as a local private entity and aimed the development of the twin cities. The local ruling classes controlled it. The council received both private and governmental funds (Chilcote 1990, American Universities Field Staff 1964).

In the 1950s, the economy of *Petrolina* was based upon agriculture (e.g., sugar-cane, manioc, castor beans, cotton, beans, corn and sweet potatoes) and cattle ranching activities. In *Juazeiro*, commerce was the most important activity. Mining of copper in the nearby region gathering of vegetal products, leather and skins processing activities mostly made up the productive activities of *Juazeiro* (IBGE 1958b). During the 1960s, in both *Juazeiro* and *Petrolina* regional factories were tanners, furniture makers, plant oil extractors, rock quarries and construction related activities. In late 1960s and early 1970s, the size of *Juazeiro*'s industrial sector was still small. *Juazeiro*'s industrial park was established in 1978 (Chilcote 1990).

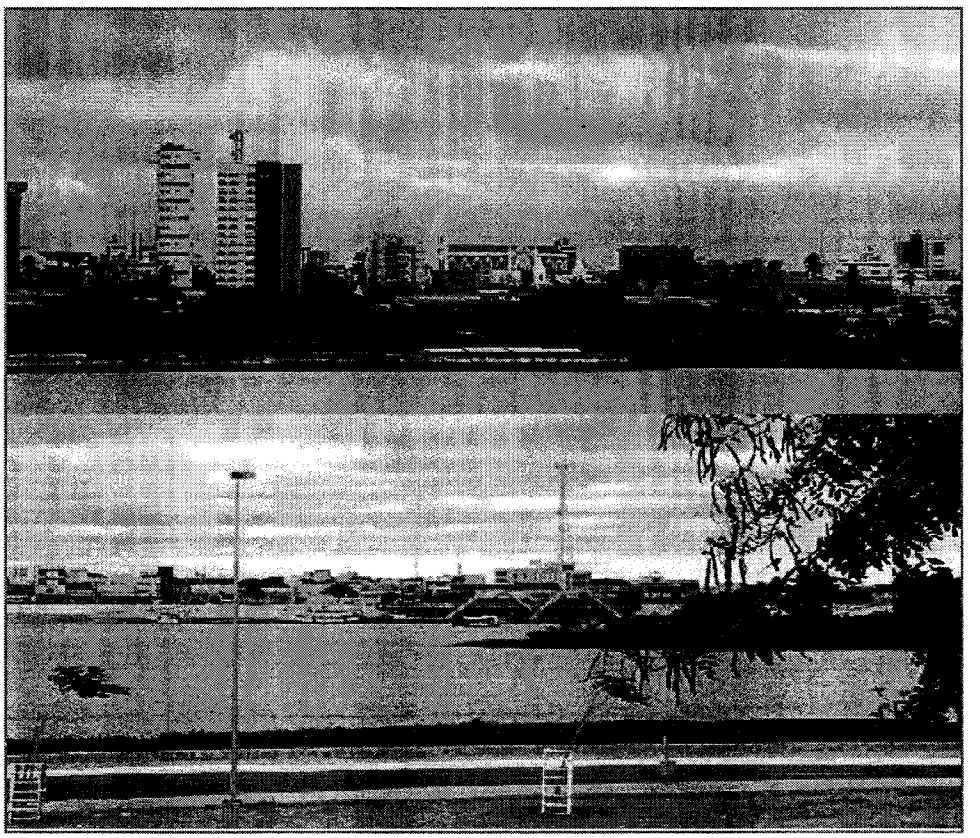

Figure 6.6. *Petrolina (Top)* and *Juazeiro*
Source: Lucigleide Nascimento 2002.

Should one say, *Juazeiro* and *Petrolina* or the other way around (*Petrolina* and *Juazeiro*)? The answer will depend on who answers the question. A sense of friendship

and rivalry has existed between the two groups of people, the *Juazeirenses* and *Petrolinenses*. In 1944, Azevedo (1946) observed an "undisguised envious" sense on the part of *Petrolina*'s inhabitants regarding *Juazeiro*. Baity also noted the feeling of "considerable competitive spirit and jealousy ... existing between them" in 1950 (Baity 1951, 94). In the beginning, *Petrolina* was only on the way between *Juazeiro* and a products' final destination (Chilcote 1990). But, the two cities' positions have shifted as regards regional influence.

In the 1950s, the *Presidente Dutra* Bridge over the SFR physically strengthened ties between *Juazeiro* and *Petrolina* (Chilcote 1990). The bridge "was built by French engineers who provided a clever pulley system with which five men can open the bridge in its middle section, allowing tall vessels to pass" (Bouquet 1967:86). Bus routes and cargo vehicles started moving between the two cities by road (IBGE 1958). *Petrolina* linked *Juazeiro* to *Pernambuco* and *Piaui* state municipalities and *Juazeiro* connected *Petrolina* through the river up to *Pirapora* and by rail and road to *Bahia*'s towns and cities (Chilcote 1990, 163).

The twin cities centered upon commercial exchange. In the 1960s, the area exported hides and skins, fibers (e.g., *sisal* and *caroa*) and wax. Raw products came from nearby areas and towns; processed and manufactured goods arrived from *Salvador* and *Recife*, the states capitals. The cities contained about 34% of all establishments and over 41% of the commercial employees of the region formed by adjacent areas of both states, meaning seven municipalities in the *Pernambucan* and ten in the *Bahian Sertão*. The twin cities were also the center for service activities, such as those provided by hotel, restaurants and repair stores (Chilcote 1990).

In late 1960s and early 70s, in his study on *Petrolina* and *Juazeiro* ruling classes, Chilcote (1990) noticed that *Juazeiro* was still a "paternalistic bureaucracy" though with competition for control among businessmen from other places. *Juazeiro* was also

dependent on capital from the outside. *Petrolina*'s development was based upon a firm patriarchal structure with the power centered in one family, the *Coelhos*.

A local newspaper in *Pernambuco* reported that some outside investors were showing an interest in *Petrolina* region in the early 1970's. These included H.J. Heinz which explored growing and processing tomatoes, the Brazilian *Pignatari* group in the *Caraíba* copper mine, the *Simonsens* in planting alfalfa on the Bahian side of the *São Francisco* River, etc. (Chilcote 1990). But Heinz's tomato project went nowhere and ultimately the Brazilian group, CICA, made the investment. The election of a "local" family member as state governor of *Pernambuco* strengthened *Petrolina* position in the region. In 1970, a paved road from *Petrolina* to the capital state, *Recife*, brought more independence for *Petrolina* from *Juazeiro* and *Salvador* (Chilcote 1990).[28]

Juazeiro and Petrolina: The River Environment. *Juazeiro* is located 370 and *Petrolina* 377 meters above sea level (IBGE 1958b). The climate is hot and dry. The cities are in the *Caatinga* biome. Their territory is entirely included in the valley's boundaries and the semi-arid region and drought polygon. The downtown riverfront in *Juazeiro* is predominantly commercial with the exception of *Angarí*, a community of fishermen and clothes washers have struggled to remain. In areas inland from the river, commercial establishments are located also at strategic points such as corners and front of streets, intermingled with private residences. In *Petrolina*, the downtown area has also both commercial and residential areas, and a riverfront park.

According to local people, the *Velho Chico* means life in the semi-arid region. The total destruction of the river would entail difficulties and even death for the local residents (Clothes washer#1, PC, 1 Aug 2006, *Juazeiro*-BA). Life depends on water and that is what they also hear from the ones living in inland areas of *Caatinga* (Cloth washer#2, PC, 1 Aug 2006, *Juazeiro*-BA). Water is the "source of life" (Irrigation-CBHSF,

[28] From 1989-91 a Coelho was the governor of *Bahia*.

PC, 13 Jun 2007, *Petrolina*-PE). The river is understood as a brave watercourse. It crosses the dry Northeast. It is development and is a bearer of miracles (Rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA).

The twin-cities relationship with the water body has been one of ups and downs. *Juazeiro* and *Petrolina* have been affected by floods. *Juazeiro* topography makes it more susceptible to floods than *Petrolina* (Lopes 1951). Flooding takes place less often today as the river's water is managed for hydropower production.

Causes of Environmental Degradation. Local residents recognize that, the *São Francisco* River's level used to be higher (rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA). Indeed, Marengo *et al.* (1998) concluded that the decrease in river flow in *Juazeiro* was due to water use for hydropower generation at *Sobradinho*. The river has lost its depth (fishermen association representative-CBHSF, PC, 03 Aug 2006, *Juazeiro*-BA). In the past, one could see and hear the waves hitting the wall of *Juazeiro*'s harbor area, in the same way as the sea acts upon coastal zone's structures (Rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA). The river has also lost its speed and has fewer waves ("*marolas*") (fishermen association representative-CBHSF, PC, 03 Aug 2006, *Juazeiro*-BA). The locals remember a free flowing river before the construction of the dams (fishermen association representative-CBHSF, PC, 03 Aug 2006, *Juazeiro*-BA). The large *Sobradinho* dam impacted fishing too, reducing the level of water and the frequency of annual flooding, but reduced flooding of the city when this fact fits with the reservoir management objective.

The concentration of people in urban zones has impacted the river too. In 1950, locals used the river for washing purposes, namely clothes washing, bathing, drinking, and waste disposal. Sewage treatment plants did not exist in *Juazeiro*. Humans discharged waste into leaching cesspools (Baity 1951). But the problem persisted. The city has had a tremendous increase in its population and not every home is linked to a

sewage treatment system. As for example, the poor district of *Angarí* discharges sewage directly into the river (fishermen association representative-CBHSF, PC, 03 Aug 2006, *Juazeiro*-BA). According to the 2000 census, some 76.5% of the homes in the urban area have improved septic systems or are linked to the city's sewage system (IBGE 2000b). The lack of sewage treatment makes it unthinkable to drink water directly from the river without treatment. By 2005, nonetheless, things had started to change. *Juazeiro* had three sedimentation lagoons (Laura 2005). But, it has not eliminated the problem completely. Untreated sewage is still discharged into the river.

Regarding garbage and refuse waste, not much seems to have changed in the city of *Juazeiro*. In 1950, local government collected the refuse by truck and deposited it in surface areas of nearby towns (Baity 1951). In January 2007 and 2010, newspaper articles have reported on the terrible state of the solid waste management in *Juazeiro*. The garbage occupied areas outside of its supposed open storage place (Laura 2007, 2010). I observed this in one of my trips to the city. Recyclers also mismanaged the area, but they are not the only ones to blame, the public authorities have not taken adequate action. Wind and rain make the problem worse. For example, plastic bags fly everywhere. Three thousand tons of garbage and refuse are deposited daily there by the waste management company. Two hundred and twenty people collect recyclable materials in the dump (Laura 2010). They are the garbage-pickers of one of the SFR Basin's biggest cities, a common phenomenon in most large cities of the Third World (Davis 2006) as well as in developing nations. Some 79% of the total homes in the city of *Juazeiro* have access to waste collection (IBGE 2009b).

Several were the environmental problems in *Juazeiro* (IBGE 2005b): water pollution (e.g., mining, animal raising, sewage, agro-toxin and fertilizers); soil pollution; decreased fish population; deforestation; burnings; erosion and silting; presence of a

large area used as an open zone for garbage and refuse disposal. The changes altered the landscape (IBGE 2005b).

In 1950, sewage treatment plants did not exist in *Petrolina* either. The form of waste management was its disposal into the *Velho Chico* (Baity 1951). In practice, it still partially occurs. Only 87.1% of the homes in the urban area treated the sewage throughout improved septic systems or using the city's management station (IBGE 2000b). According to a local environmentalist, Vitório Rodrigues, *Petrolina* "pollutes more than *Juazeiro*" (Laura 2005, 17). But, the city is increasing the number of sedimentation lagoons in activity.

In *Petrolina*, in 1950, the local government collected but then disposed of garbage on the river banks outside of the city (Baity 1951). In 2007, the city was working on the management of garbage and refuse, restoring the open area used for disposal, creating a green belt around it, and implementing recycling alternatives (NGO/member/local public government staff/environmentalist, interview 13 Jun 2007, *Petrolina*-PE). The local government collects 93% of the garbage of the town (IBGE 2009b).

Aquatic plant species, known as *Baronesa* (*Eichornia crassipes*), have had an accelerated growth in the area between *Petrolina* and *Juazeiro* due to the river's high nutrient content, partially from sewage discharge. The *Baronesa* develops mainly on the *Pernambuco* side, due to its slower current. The problem impairs the use of the river aesthetically. It leads to health issues, such as the increase in mosquito populations. It also impairs navigation (Laura 2005).

Agriculture and Other Related Non-point Sources of Pollution. In the 1950s, the *Juazeiro* area produced onions, rice, sugar-cane, castor beans seeds, cotton and fruits and in a smaller-scale, manioc, coffee, beans, tomatoes and vegetables (IBGE 1958b). Farmers in *Petrolina* grew almost the same products, sugar-cane, manioc, castor beans

seeds, cotton, beans, corn and sweet potatoes (IBGE 1958b). Potatoes, pumpkins and watermelon grew on riparian lands with the *São Francisco*'s waters. But, new projects have changed and increased the area of agriculture (Clothes washer #2, PC, 1 Aug 2006, *Juazeiro*-BA). The cause of such phenomena was irrigation. The river provides electricity necessary for the pumps. "Water reaches everywhere" (Clothes washer #1, PC, 1 Aug 2006, *Juazeiro*-BA). The zone produced even new sorts of fruits, such as *acerola* (*Malpighia glabra*) and strawberries (Clothes washer#2, PC, 1 Aug 2006, *Juazeiro*-BA). But agriculture also employs fertilizers and agro-toxins polluting the environment, and causes salinization and silting on both sides (IBGE 2005b).

Large-scale irrigation in the *Petrolina-Juazeiro* agro-industrial pole started in the late 1960s and early 1970s (Barros *et al.* 2004). Large public investments were made in the region during the 1970's (Silva *et al.* 2000). The construction of the *Sobradinho* dam and reservoir for hydropower generation in the 1970s, led to flooding of towns and farms. But it also brought benefits, such as, irrigation systems with canals and pumping stations (Collins 1993).

The Northeast, especially the *Petrolina-Juazeiro* agro-industrial pole has a large place in the production of fruit at the national level (Cardoso and Souza 2000).[29] In the mid-1970s, industries in the *Petrolina-Juazeiro* area began processing tomatoes, juices, making jam and candies (Silva 1985). Fruit production has been labor intensive (Collins 1995, Cavalcanti 1996). It has required skilled people. It has employed family members, as well as temporary and permanent workers (Collins 1995). Fruit production has been technically sophisticated, but innovations, such as machinery, have not yet being able to replace humans in activities such as pest monitoring, trimming and harvesting (Collins

[29] "The waters of the São Francisco River are producing a new promised land in northeastern Brazil. Instead of milk and honey, one finds the sweetest and juiciest fruits ever grown in the country. The key to this agricultural success is irrigation, which, in a little more than a decade, has transformed Brazil's hot, arid sertão region into a verdant orchard. The controlled water flow makes fruit mature more quickly and allows for larger and more frequent harvests. In 1993, the region produced 80,000 tons of fruit, earning some $40 million for its 30 exporters" (Nanne 1994: 44).

1993, 1995). A division of labor has existed in Brazilian fruit production and the workforce has been unequally distributed across gender lines. In the case of grape production in the *Petrolina-Juazeiro* pole, the workforce has been composed mostly of women (Collins 1995).[30] In the case of mangos, men have been preferred with women participating in the final phase of the productive process, selecting and packing the fruit for export (Cavalcanti 1996).

The agro-export pole is located at 770 kms from *Recife*, 520 km from *Salvador* and 850 kms from *Fortaleza* 850 km (Silva *et al.* 2000b); and ports (e.g., *Salvador* in *Bahia*, and *Suape* and *Recife* in *Pernambuco*). These cities are geographically closer to European and North American countries than are south and southeastern parts of Brazil (Codevasf 1989b). The pole was also closer to a permanent source of water, the *São Francisco* River/*Sobradinho* Reservoir.

In late 80s, the *Petrolina-Juazeiro* pole accounted for almost half (49.1%) of the total irrigated area in the *São Francisco* River Basin, with private complexes surpassing public projects (Codevasf 1989). In 2005, the pole comprised about 120,000 hectares of irrigated land (VALEXPORT n.d.b.). Irrigated agriculture requires a high rate of capital investment, the use of fertilizers and agro-toxins and machinery (Maffei *et al.* 1986).

Grapes and mangos are the most important products *in natura* exported to supply the high-quality level of demand abroad (Silva *et al.* 2000).[31] Over half of the zone planted with mangos in the basin is in *Petrolina-Juazeiro* Pole (Lopes *et al.* 2004 citing CODEVASF 1999). In the *São Francisco* Valley, "[g]rapes were first exported on the experimental basis in 1985", and commercially in 1987 (Collins 1995: 1105). Grapes

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[30] According to the nimble fingers argument, "[w]omen are considered not only to have naturally nimble fingers, but also to be naturally more docile and willing to accept tough work discipline, and naturally less inclined to join trade unions, than men; and to be naturally more suited to tedious, repetitious, monotonous work" (Elson and Pearson 1981: 93). Damiani (2003) recognized that irrigated crop production in *Petrolina/Juazeiro* pole has benefited both rural workers (i.e., year-round production and revenue) and farmers (e.g., employment opportunities, wage higher than Brazilian minimum wage and social security benefits).

[31] Staff of the transportation company, *Viação do Brasil* noticed in 1896 that the *Sertão* had three grapes seasons per year and it was the land for grape plantation (Machado 2002).

produced in the valley had two major annual harvests (Collins 1995). This fruit replaced tomato plantations especially after a 1989/1990 conflict between tomato producers and buyers (Collins 1993). Mangos were also first exported in 1987 (VALEXPORT n.d.a). Exports were carried out by individual farmers, by associations (e.g., VALEXPORT[32], BGMB[33]), and through export businesses (e.g., a French government company - Cacique) (Collins 1993, Collins 1995). "The mangos of the São Francisco valley entered the European market precisely in the unsaturated October to January season filling a market niche. Now some producers already are able to obtain fruit almost all the year round applying new cultivation techniques" (Voth 1999:9). It implied more water being used in irrigated fields. According to Hirsch (2005), in the beginning of the twenty-first century, the export of mangoes had one window. Most sales abroad took place from July to December. Grapes are exported during two annual periods. Most sales took place from April to June and October to December (Hirsch 2005).

Mangos and grapes are perishable goods and require specific forms of preservation, storage and transportation. After harvesting, the fruits underwent several phases in 'packing houses', where they were selected, treated (e.g., submerged in hot water in the case of mangos), packaged and refrigerated (Correia *et al.* n.d., Valexport n.d.b.). Fruits from the SFRB region were mostly brought to ports by trucks in refrigerated containers, and then shipped by boat (França 2000, Hirsch 2005). Transatlantic shipment of fruit to Europe took from 10 to 12 days (Voth 1999). "Grapes are most often shipped by air, while melons, papaya, mangos and vegetables are shipped by boat in refrigerated containers" (Collins 1993:79). The commerce has been made possible due to the increase in the quality of the region's air-transportation system (Silva *et al.* 2000b),thanks

[32] The VALEXPORT, created in 1988, has today 55 members, which represent about 70% of the total amount of fruit produced in the *São Francisco* River Basin, and 80% of the amount exported (VALEXPORT n.d.b).
[33] BGMB, Brazilian Grape Marketing Board or BGMA Association, was created in 1992 (Collins 1995), composed by grapes producers to easier export through tools such as fixing the price and bulking export (Collins 1995).

to the improvement of the *Petrolina* Airport in 2004 (INFRAERO n.d.). The airport could handle large cargo aircraft and had cold-storage facilities to preserve the quality of the fruits before transportation (Correia *et al.* n.d.). The same cannot be said for aquatic and land transportation (Silva *et al.* 2000b).

The *São Francisco* River Basin water bodies have been losing their navigability due to many causes. In addition, the "navigable stretch" of the SFR, in which the *Petrolina-Juazeiro* region is located on, does not link the pole to coastal cities, and is not used for fruit export (França 2000). The low level of highway maintenance is a major problem throughout Brazil and especially in the SFRB (personal observations: July 2002, August 2004 and August 2006; França 2000).

Nonetheless, the quality of land transportation can change. In 2005, the *Companhia Vale do Rio Doce* – CVRD shipped fuel over the *Juazeiro-Salvador* rail link (*Centro-Atlântica* Railway) (Hirsch 2005). The railroad was also linked to *Propriá* in the lower-SFR. In addition to that system, in July 2006, a project to restore part of the existing railroads and build a new one (*Transnordestina*) to link the rural zones of the Northeast to coastal ports such as *Pecém* in *Ceará* and *Suape* in *Pernambuco* began (Folha de Pernambuco 19 July 2006). The railroad will go as far as *Petrolina* linking it with *Salgueiro* located at 231 kms northwest in the same state.

The Fishery. In 1919, Bahia Illustrada (Apr 1919) reported upon the abundance and size of fish and species found in the *São Francisco* River. In the *Juazeiro* region, there were *Surubins* weighing 200 and 300 kilos. At that time, *Pocomans*, *Mandys*, *Bagres*, *Trahyras*, *Dourados*, *Piranhas*, *Pacus*, *Corvinas*, *Piáus*, and *Matrinchã* were common. The price of the fish was very low (Bahia Illustrada 1919). By the 1950s *Surubim*, *Dourado*, *Pirá*, *Mandim* and *Curimatá* were the important species (IBGE 1958b).

Besides the effects of the dams, fishermen themselves had directly contributed to the degradation of fishing in the SFRB. Braga (1982) mentioned the use of destructive

catching techniques on the *São Francisco* in the 1949-54 period as one possible cause of the decrease in the *Matrinchã*. Another cause could have been the reduction of its food supply. Fishermen continued to contribute to the problem by using illegal fishing equipment to catch undersized fish (Alixandrino 2003). Exotic species, such as *Tucunaré* has also threatened the local species.

Velho Chico's fish stock has continuously declined. The impacts on fish have increased. Fishermen complained about the lack of fish in the lower-middle region of the SFR. They have listed some of the causes as well: shallow river, many sandbanks, slow flow of the river, wide riparian zones. In addition, riparian lagoons do not exist anymore and garbage and refuse are frequently present (Alixandrino 2003).

Seeking ways to cope with the problem, regional fishermen migrate to work in the *Sobradinho* Lake, where the fishery is more professional and fish still exist (Alixandrino 2003). A fisherman from *Angarí*, a riverfront neighborhood in Juazeiro, remembers that forty years ago, fishing and clothes washing were the major economic activities of the area (fishermen association representative-CBHSF, PC, 03 Aug 2006, *Juazeiro*-BA).

Other Ecosystem Services. In 1917, Juazeiro received electric illumination (Chilcote 1990). Energy lightened *Petrolina* nine years later (CONDEPE 1987). In 1944, the system supplying energy to the twin city worked only until 11 p.m. (Azevedo 1946). Hydropower generation improved in the 1950s. Diesel-driven generators located on an island, *Ilha do Fogo*, between the two cities, supplied their electricity (Baity 1951, Clothes washer #2, PC, 1 Aug 2006, *Juazeiro*-BA). The first phase of the project started working in 1956 (Serebrenick 1961). Each city provided the fuel for their respective systems which worked from 5 p.m. to midnight. The CVSF had built the station (Baity 1951). In 1964, the *São Francisco* started to provide hydropower to the twin cities. *Juazeiro* and *Petrolina* benefited from the construction of transmission lines from *Paulo Afonso* (SUVALE 1968a).

Today not only the cities, but the Northeast and various parts of the nation receive power generated in the basin.

Water Supply. In early twentieth century, the *aguadeiros* supplied *Juazeiro* by carrying water in barrels on donkey's backs (Bahia Illustrada Apr 1919). The method lasted until mid-century. In the early 1940s Duarte (1971) and Baity in 1950 (1951) noted that public water supply still did not exist in *Juazeiro*. Locals carried water from the river themselves in jars and cans, or on the backs of donkeys (Baity 1951).

Professional water carriers charged according to the distance from the river. People collected the water from the dirtiest part of the river affected by runoff, sewage and other forms of waste (Baity 1951). Azevedo observed the same water supply system, the work of water carriers, taking place in *Petrolina* in 1944. He also observed women washing clothes along river bank (Azevedo 1946).

In both cities the *São Francisco* provided the resource carried by humans and animals (Baity 1951). FSESP and CVSF built a WTP in Petrolina in 1965 (SUVALE 1968a). An interviewee still remembers the time when local people collected water from a river fountain (Clothes washer#2, interview, 1 Aug 2006, *Juazeiro*-BA). Today, the water treatment station of *Juazeiro*, SAAE uptakes 526 m^3/s from the *Velho Chico* (Water treatment plant staff, PC, Aug 03, 2006, *Juazeiro*-BA).

The floating uptake system is located on a barge. It adjusts itself accordingly to the level of the river (WTP staff, PC, 14 Jun 2007, *Petrolina*-PE). The WTP is located in the *Santo Antônio* district, near the *Grande Hotel de Juazeiro*. The water undergoes a continuous four-hour conventional treatment before arriving at pre-distribution reservoirs (clarification/flocculation, filtration, disinfection, addition of Fluoride) (Water treatment plant's staff, PC, Aug 03, 2006, *Juazeiro*-BA).

The water was tested for standard water quality indicators (e.g., color, turbidity, ph, purity, salts). However, the station did not test the water for agro-toxins. When there is

suspicious of pollution, samples are tested in *Salvador* and *Recife*. Every three months the water was tested for heavy metals (Water treatment plant's staff, PC, Aug 03, 2006, *Juazeiro*-BA). In the urban zone, 96.2 % of the homes have access to the city's water supply system (IBGE 2000b).

The *Pernambuco* State Water and Sewage Company - COMPESA, supplies water to *Petrolina* (Abastecimento Urbano-CBHSF, PC, 17 Nov 2006, *Recife*-PE). The city has two fixed systems of water uptake. The water treatment is conventional. But, COMPESA does not add fluoride. Some 97.8% of the homes in the city are linked to the municipal water treatment plant (IBGE 2000b) (WTP staff, PC, 14 Jun 2007, *Petrolina*-PE). A creek, *Riacho da Vitória*, crossing irrigated lands, flows into the *São Francisco* upstream of the uptake area. During winter, the level of salt is high, and has to be reduced. Part of the water treatment occurs outdoors (WTP staff, PC, 14 Jun 2007, *Petrolina*-PE).

In 2004, the National Water Agency granted the state water treatment facility the right to withdraw the maximum amount of 500 L/s for the purpose of public supply until 2025 [ANA Resolution # 233 of May 11of 2004, Art. 1, Art. 2].

Deforestation, Erosion, Siltation and Navigation. *Sobradinho* waterfalls were a natural obstacle against navigation. Burton mentioned the existence of *Rápido do Sobradinho* also known as *Vidal Afonso*, *Cachoeira Criminosa* and *Cachoeira do Bebedor*, besides smaller rapids (Burton 1977). Various islands also existed, such as *Santana* and *Cachoeira* (Sampaio 2002).

Before the construction of the Sobradinho hydroelectric facility at least four waterfalls interrupted the river's flow (Sampaio 2002). According to Rocha (1983), in the 1930s, cargo had to be transferred to smaller boats to allow passage. In the 1950s, the port of *Juazeiro* was the largest of the region (IBGE 1958b). The port was moved upstream when *Sobradinho* was built in the 1970s. But, public outcry demanded return of the port to *Juazeiro*. Despite the improvement in the falls area due to the construction of

locks, navigation was never as before. The old boats then did not fit with the new environment (e.g., deeper lake, more waves) (NGO representative, PC, 03 Aug 2006, *Juazeiro*-BA; Boat pilot, PC, 20 May 2007, *Pirapora*-MG; Mechanic/boat driver, PC, 02 Aug 2006, *Juazeiro*-BA).

In 1893, Vianna (1893) had reported the existence of trees around the port of *Juazeiro*. A half century later, the absence of trees around *Juazeiro* was noticeable. Low vegetation characterized the deforested area. But it was still possible to find scattered trees such as *Baraúnas*, *Aroeiras*, *Pau-ferro*, *Jatobá* and *Caraíba* (IBGE 1958). Lower and deciduous trees and scrubs forested the inland zone around *Juazeiro* and *Petrolina*. They were green during and soon after the rainy season. But, riparian vegetation became more the exception than the rule. Vegetation was also used for fuel (Engenheiros e Economistas 1957).

Other Impaired River Uses: Cultural Values, Aesthetic Enjoyment and Tourism. In the 1950s, the port zone of *Juazeiro* attracted tourists and local residents. The port was regarded as a socio-economic and cultural symbol of the region, including the public market. The island, *Ilha do Fogo*, used to be a tourist and leisure site for inhabitants of the twin cities. This land is now part of the bridge's foundations and a ship yard (IBGE 1958b).

Many still enjoy the beauty of the river (Clothes washer #1, PC, 1 Aug 2006, *Juazeiro*-BA). Some use the river for religious purposes too. "People hold parties in the river ... offer flowers... it is a very beautiful ceremony" (cloth washer#2, PC, 1 Aug 2006, *Juazeiro*-BA). A large sculpture of a legend of the waterway, the *Negro d'Água* stands in the river. Local residents associate other symbols with the river too, such as the *Carrancas*, a traditional vessel's bows. The city of *Juazeiro* selected an official day to celebrate such icons (Rural workers association representatives, PC, 03 Aug 2006, Juazeiro-BA). These things illustrate the lasting importance of the river and its representations in the popular culture.

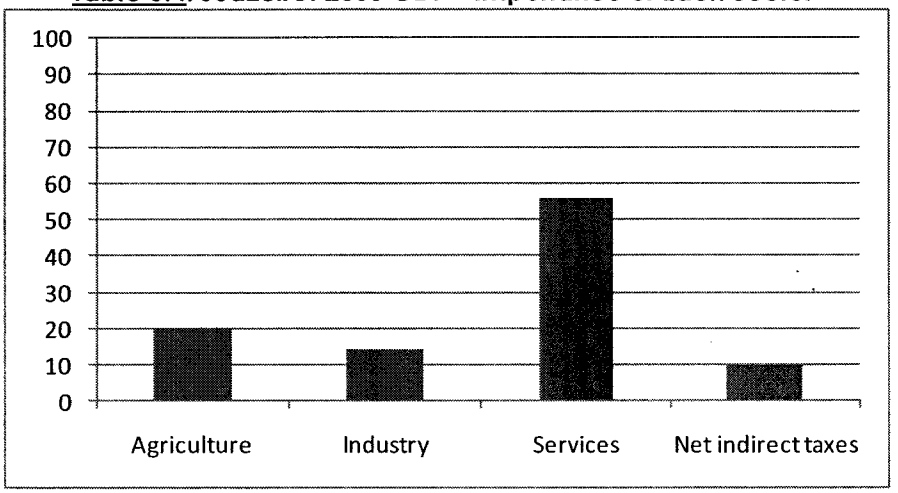
According to an interviewee, locals' beliefs helped to protect the waterway in the past. "There was a serpent in the *Ilha do Fogo*. Today, no one talks about it anymore. All of that was a form of respect for the river. In the past, people did not do what they do today to the river. They were afraid" (Rural workers association representatives, PC, 03 Aug 2006, *Juazeiro*-BA). Nevertheless, such beliefs could not prevent influences and interventions in the river's environment.

Other variables in addition to environmental changes influenced the use of the river resources. Washer women in *Juazeiro* stopped washing and bathing on the riverfront in the *Angarí* neighborhood because of transformations and violence (cloth washer#1 and clothes washer #2, PC, 1 Aug 2006, *Juazeiro*-BA). Because of the bad guys, the *malandros*, they said, "we do not play in the water anymore (Clothes washer#2, PC, 1 Aug 2006, *Juazeiro*-BA). The violence of modern urban life has arrived in the SFR valley. The watershed has one of the most dangerous roads in Brazil, located on the *Pernambuco* side of the river, known as Robbery Road. It crosses through the Marijuana Polygon.

How developed are *Juazeiro* and *Petrolina* Today? In 2007, 230,538 inhabitants lived in *Juazeiro* and 268,339 in *Petrolina* (IBGE 2009a). A tremendous population growth has taken place in both cities. The configuration of the gross domestic products of the twin cities is very similar. In 2006, in *Juazeiro*, agriculture accounted for 20% of the GDP. Services accounted for 56%, which include activities related to commercial hydro-businesses. This was not much different in *Petrolina*. Agriculture accounted for 21% and services for 57% of the GDP (Table 6.4 and 6.5 below). In 2006, in *Juazeiro*, agriculture (13%) and industry (13%) together employed fewer people than commerce did alone (IBGE 2006b). In *Petrolina*, agriculture employed more, 17% and industry less, 7.64% than was the case for *Juazeiro* (IBGE 2006b). Commerce had 29% of all employees (IBGE 2006b).

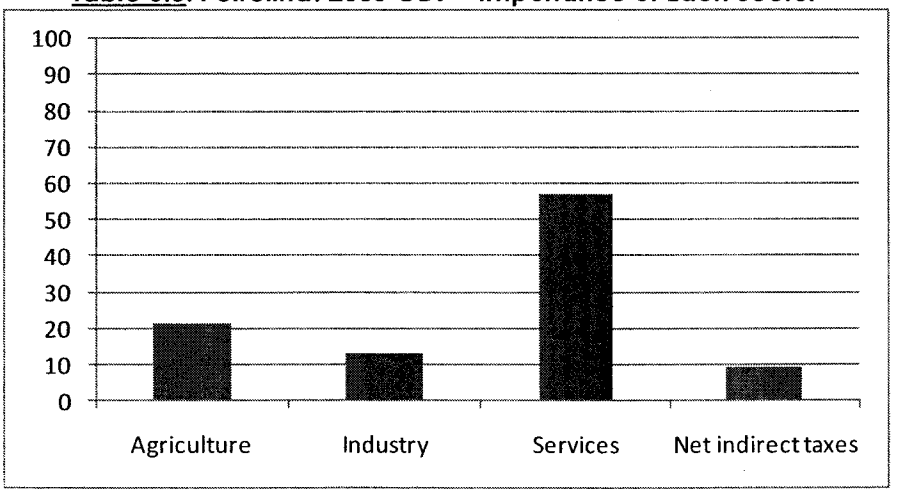
Mangos and grapes are not the only products of the twin cities. In 2008, *Juazeiro* produced 1,367,916 metric tons of sugarcane; 51,858 metric tons of onions thereby maintaining its tradition as one of the first irrigated agricultural products; and only 15,468 metric tons of cassava (IBGE 2009a). Petrolina produced 67 thousand metric tons of guavas and 45 thousand metric tons of bananas (IBGE 2009a). The numbers show the tendency toward agri-businesses or hydro-businesses.

Table 6.4. *Juazeiro*: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

Table 6.5. *Petrolina*: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

Despite the similarity in the configuration of the gross domestic product of the twin cities, the Human Development Index reveals a different reality. *Petrolina* has a higher level (0.747), while *Juazeiro* falls far behind (0.683). The major problem with *Juazeiro* is its low life expectancy at birth (PNUD 2000a). *Juazeiro* local government is reducing infant mortality rates increasing population's access to health and sanitation systems and education (Castro 2010).

Conclusions. Historically, the *Velho Chico* has united and divided the two cities. The area was first known as the site to cross the river. Ferries still run regular services linking *Petrolina* and *Juazeiro*. But river commerce is not part of the socio-economic dynamic anymore. A bridge connects the two. This section described the trend in the use of the *São Francisco*'s Resources around the twin cities of *Juazeiro-Petrolina*, emphasizing the transition from the local with navigation and fishing, to regional, to national and global with hydropower and irrigation. Irrigated agriculture is not the new key for the economic growth of the region, because it has changed communities and the environment of the region.

The City on the Cliff: *Penedo*

Introduction. *Penedo* is a lively and colorful old city that still maintains a colonial style construction in addition to a few islands of 'modernity' (Figure 6.7 below). The building of a fancier hotel in town provides a prime spot for scenic river appreciation and picture taking. But it stands as an alien in the region. *Penedo* is about an eight-hour bus trip far from *Salvador*, with a short stop in *Aracaju*, the capital of *Sergipe*. Using this access route, one crosses the bridge over the *São Francisco* to arrive in the *Alagoas* side of the basin. It is a long, at times bumpy and exciting trip.

After observing the initial higher part of the city, one arrives in the town's bus station in the lower district.[34] The steep road in the hill and the speed of the bus make one think that the first encounter with the river's water will occur sooner than the tourist wishes.

Penedo is the oldest city of the entire SFR basin. The village dates to 1613. Portuguese and Dutch fought for the land. Franciscan missionaries also inhabited the region (CODEVASF 2001). The location of the city over a cliff gave the name *Penedo* to the place. Its past denominations include *São Francisco* and *Vila de São Francisco* (IBGE 1959). The area came to be an official city only in 1842 (Codevasf 2001). In a straight line, *Penedo* is located 115 kms away from the *Alagoas* capital, *Maceió*. It is 187 kms away from it by road (IBGE 1959b).

Figure 6.7. *Penedo*
Source: Lucigleide Nascimento 2007

[34] I have visited *Penedo* twice. The first time was during a preliminary trip in 2004. The second stay occurred during fieldwork in 2007.

The socio-economic history of the city is directly linked to the *Velho Chico*'s seasonal change. Already in 1879, Sampaio had observed fields of the major agricultural product of the region, rice. Farmers grew rice in areas which the river inundated (Sampaio 2002). *Penedo* has been a commercial city. In the end of the nineteenth century its market attracted many selling and buying the agricultural products of the region. They traded cotton, sugar, skins, hides and leather. The city was the site for manufacturing too. This included leather, soap, cigarette and cotton processing facilities; and small machinery and carpenter shops (British 1896). *Penedo* had a busy port of local and regional importance. In late 1930s, dockworkers loaded cotton, rice, beans, corn, wood, and cattle from the *Sertão* into ships leaving to other states such as *Ceará* and *Rio Grande do Norte* (fishermen-CBHSF, PC, 17 Jan 2007, *Penedo*-AL).

In 1950, *Penedo*'s port authority registered the existence of 231 vessels of different sizes and type able to carry from 100 kilos to 50 tons (Pierson 1972, vol. 2). The place was still the most important commercial and port city of the region (IBGE 1960b). In the late 1950s, railroad and road systems also connected the lower-SFR with the outside world (IBGE 1960b). Roads linked the city to other places, such as the adjoining states capitals (IBGE 1959b). *Leste Brasileiro* railroad linked *Propriá*, a city upstream and in the *Sergipe*'s side of the river, with *Aracaju* and *Salvador* (Baity 1951, CVSF 1957).[35] The railroad linked *Bahia* (*Salvador*) to the lower-SFR, *Aracaju* and *Propriá* in 1913 (Westphalen, Bach & Krohn 1928). Before the construction of the bridge, in 1972, connecting the two states in the towns of *Propriá-Porto Real do Colégio*, diesel-operated barges linked *Sergipe* and *Alagoas* state. The road connected other Northeastern capitals, such as *Salvador* and *Recife* (Bouquet 1967, Propriá 2009).

Penedo is 689 sq. kms large (IBGE 2009a). *Penedenses* are the people born in the city. According to the 1950s census, 20,762 individuals inhabited the city, the second

[35] *Companhia Ferreviária do Nordeste* – CFN is restoring the railroad from *Propriá* to *Maceió*. Now, the *Ferrovia Centro-Atlântica* connects *Salvador*, *Aracaju* and *Propriá* (transporte.gov.br visited on 27 October 2009).

highest population in the state of Alagoas only after the state capital (IBGE 1950+). Historically, the fishery was intensive and economically important, as well as agriculture and cattle in the SFR's riparian zone including on islands (IBGE 1959b). The local population used *São Francisco*'s lagoons to grow the most important local agricultural product, rice (Baity 1951, IBGE 1959b). In the late 1950s, the major crop also grew in naturally irrigated flooded zones and in areas where the development agency for the valley, CVSF had introduced mechanized agriculture (IBGE 1960b).

Penedo exported rice to the state capital and other places of the north and south regions. Manioc was a subsistence crop. Mangoes, beans, corn and sugar-cane also figured among agricultural outputs. In the 1950s, manufactures produced coconut and castor oil from local raw materials, and textile. The food industry processed manioc, rice, coffee, sugar and corn. Local residents also produced charcoal, handcrafts made of fibers, supplies for the fishery industry and clay materials, such as tiles and bricks (IBGE 1959b). The village of *Brejão*, in *Brejo Grande*, supplied *Penedo* with *junco*, the fibers for art crafts. The local population used the mats (*esteiras*) made of *junco* as bedding, seats, shades, and even to bury the dead (Araújo 1961). Stones represented the mineral richness of the area. The city was an important center for commerce and banking. It has a long history of citizen participation based upon associations. In 1950s, the city had artists, fishermen (*Colônia de Pescadores São Francisco – Z-12*) and agriculture workers' associations (IBGE 1959b).

The River Environment. The climate is tropical humid (Mascarenhas *et al.* 2005). The highest temperature is about 90°F and the lowest 72°F (CODEVASF 2001). The annual average rainfall volume was of 64.33 inches. Upstream, in the lower-middle-SFR the average precipitation is 27 inches per year (Mascarenhas *et al.* 2005, CBHSF 2004). *Penedo* is about 40 kms away from the river's mouth and some 730 kms downstream of *Juazeiro* (Zarur 1946). *Penedo*'s jurisdictional boundaries are integrally inserted in the

valley. It contains elements of both steppe and Atlantic Rainforest biomes. It was located about twenty seven meters above sea level (Mascarenhas *et al.* 2005).

Causes of Environmental Degradation. In 1950, sewage treatment did not exist in *Penedo*. A precarious system collected part of the sewage, but did not treat it, discharging it in raw form into the river. Those without access to the system used pit privies and cesspools or no other form of management at all (Baity 1951). In the present days, sewage still contaminates the water (IBGE 2005b). The water that reaches the treatment station was of bad quality. As the staff of the local water treatment station said, the watershed is highly populated and many towns and cities, including this one, do not have sewage treatment stations (Water treatment plant staff, PC, 17 Jan 2007, *Penedo*-AL).

The 2000 census showed that only eighteen percent of homes in town have improved septic system or are linked to *Penedo*'s sewage network (IBGE 2000b). But that does not imply that the city treats it. In 2007, SAAE received the warrant of discharging the maximum of 507.87 m^3/h (141.87 L/s) of treated sewage into the *Velho Chico* until December 2026 [ANA Resolution# 400 of 2007]. In 2010, the city was still building a sewage treatment facility.

Regarding solid waste, the situation has improved but in slow steps. In 1950, the city collected garbage and refuse disposing the waste at open surface dump (Baity 1951). It took almost a half-century for the construction of a seven hectares managed site to deal with the forty tons of daily waste (PNUD 2004). The city collects the garbage from 96% of homes in town (IBGE 2009b).

The control of the river flow by dam management has altered the flooding dynamic. It has destroyed two major local socio-economic activities: rice and fishing. Changes in the river's cycles have damaged the rhythm and possibilities of fields in the lagoons, which produced both fish and rice (CODEVASF staff, PC, 27 Nov 2006, Recife-

PE). But, the effects were not a surprise. The development agency for the valley, SUVALE, and the hydropower agency, CHESF had predicted that hydropower infrastructure, such as *Sobradinho* would affect the rice fields of the lower-SFR. The agencies planned the construction of six irrigation zones to replace the so called "Vietnamese culture." But they did not build the projects as they had planned and did not benefit everyone previously involved in the rice activity (CODEVASF 2003). Members of the local population have observed several changes in the river environment. According to them, the level of the river's water used to be higher (small farmer/bus driver, PC, 19 Jan 2007, *Penedo*-AL). Now, in some places the area is flooded most of the time. In others the water course moved far away (Small farmer businessman, PC, 19 January 2007, *Penedo*-AL,). The river is controlled by man, "during the dry season, the water does not come" to the lower-SFR (Head of fishermen association, PC, 17 Jan 2007, *Penedo*-AL). In 2004, I visited the local supermarket in *Penedo*, in a building the CVSF once occupied, and discovered that *Rio Grande do Sul*'s rice now supplies it. But, at least the public market still sells part of the local rice production.

The lower-SFR is the region which has been most affected by anthropogenic interventions on the *São Francisco* River environment along its course. The collapse of the fishing industry is one of the indicators (CODEVASF staff, PC, Nov 27, 2006, *Recife*-PE). In addition, economic alternatives, namely irrigation projects, which sought to mitigate the social problems that dams would cause, introduced other environmental and social impacts. The changes have impaired water-based transportation too. Navigation is now a challenging task.

Agriculture and Other Non-Point Source of Pollution. It became difficult and sometimes impossible to practice riparian agriculture given the new water regime. The local population used the lagoons to grow rice. The plantings used to be seasonal. These occupied about six months of the year and involved the entire family (fisherman-CBHSF,

PC, 17 Jan 2007, *Penedo*-AL). As mentioned, irrigation projects in the lower basin were an attempt to address the problems generated by the regularization of the river (CODEVASF staff, PC, 27 Nov 2006, *Recife*-PE). In addition, the CVSF introduced new mechanized processes. Tractors replaced the work of many family members, renters and other workers. As an example, in 1959, the so named mechanized patrol, "*patrulha mecanizada*," worked on 5,306 hectares in *Penedo* accounting for the largest area in the valley (Serebrenick 1961). The mechanization reduced the workforce needed and employed.

In the 1950s, the lower-SFR, multiple cultures including rice had replaced the monoculture of sugar-cane and its mills of the colonial and post-colonial eras (Araújo 1961). The area is now following an inverse trend. Sugar-cane occupies large extensions of the lower-SFR region. Both grass for cattle and sugar-cane fields now take up the areas once occupied by riparian lagoons (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). Agro-toxins pollute the river and sink holes (IBGE 2005b).

The Fishery. The fishery has been important part of the local economy and society of Penedo and in many other cities of the lower-SFR. Locals caught fish and other aquatic species such as shrimp. In 1955, fishermen of the local association, *Colônia de Pescadores São Francisco*, caught 125 tons of fish. The number shows the level of such activity. Fishery was an intensive but rudimentary activity. In the 1950s, *Piranha*, *Curimatã/Xira* and *Surubim* were the most important fish species (IBGE 1959b). Animal carts, cars, and boats transported fresh and salted fish to supply local markets and nearby cities. Fishermen sold fish and also bartered it for other product, such as beans, tomatoes, and green vegetables. According to a local fisherman, the river environment provided a good life. "The life of the river used to be such a life" (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL).

Flooding used to allow the entry of small fish into lagoons, which acted as a nursery. The lagoons are not flooded by the river's water anymore. Rainfall forms lagoons, but not as in the same way it used to be. Fishing was not as prominent as in the past. According to one of "the best" fishermen in town, as recognized by himself and by his peers, sometimes he stays out in the river for hours and returns home without any fish. That reality is shared by other fishermen too.

Many still survive from the river. For some the river is like a good boss (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). For others it is a large company because millions of people live from the river (Fisherman, PC, 18 Jan 2007, *Penedo*-AL). In the past, "it was a major industry for fishermen," today problems exist because of the existence of dams (fisherman and NGO member, PC, 19 Jan 2007, *Penedo*-AL). Another social problem is that in the past, fishermen were professionals. Today, the lack of jobs in other areas has led many to fishing. "Today it is difficult to sell fish. There are more sellers than buyers" (Fisherman, PC, 18 Jan 2007, *Penedo*-AL).

In addition to the change in the hydrologic regime, water pollution and destruction of habitat have caused a decrease in quantity and diversity of aquatic species available (IBGE 2005d). The presence of an algae species in large amounts has also been impairing fishing. *Rabo-de-raposa* develops in the clean and shallow water and hides fish (Head of fishermen association, PC, 17 Jan 2007, *Penedo*-AL). *Maçuni* a shell fish species have also expanded at a fast pace in parts of the lower-SFR. Invasive fish species such as *Tucunaré* also exist in the region. Water pollution has killed the black earthworms, an element of the ecosystem and food-chain (Fishermen-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). Fishermen used them to attract fish.

Other Ecosystem Services. The local environment provided shelter to a diversified fauna including birds (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). The end of lagoons destroyed their habitats. Birds used to get so fat that they could not fly and were

caught by rice planters, who also caught the fish from the same lagoon. An interviewee expressed that fact with a traditional song: "*Paturí*, what are you doing around this lagoon? ... The ones that have wings fell into hunting bowknot. Can you imagine what can happen to the ones that cannot fly? (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL).

In 1950, gasogene converter and diesel engine supplied the city twenty four hours a day, but the demand surpassed supply (Baity 1951). In 1958 the *São Francisco* started to provide hydropower to *Penedo* (CHESF 1970).

Water Supply. In 1950, the water supply system of *Penedo*, which withdrew water from the *São Francisco*, included a motor-driven pump and a small distribution system. But, the arrangement did not treat the water (Baity 1951). The existing water management institution named *Serviço Autônomo de Água e Esgoto* – SAAE of Penedo dates from 1957. It began as a federal entity, but became an independent agency of the municipal government. *São Francisco River*'s water underwent a conventional primary treatment (coagulation, flocculation, settling, filtration, disinfection, and addition of Fluoride). SAAE started to add fluoride to the water in 1988, and the fact has reduced the incidence of tooth cavity and decay conditions (Water treatment plant staff, PC, 17 Jan 2007, *Penedo*-AL).

In 2007, the National Water Agency granted SAAE the right to withdraw 895m^3/h (248.61 L/s) for the purpose of meeting the public's demand for water [ANA Resolution# 400 of 2007]. Some 93.7% of homes in the urban zone are linked to the city's water supply system (IBGE 2000b). The municipality of *Penedo* also has twenty-five small scale water wells (Mascarenhas *et al.* 2005).

The water uptake took place in *Rocheira* nearby a sewage pipe of a local restaurant. Monthly reports from the water treatment plant of *Penedo* indicated the presence of total coliform and *Escherichia Coli* (E. coli) in the water prior to its treatment

(Penedo SAAE 2005-06). Regarding contamination by agro-toxins, SAAE did not test them (Water treatment plant staff, PC, 17 Jan 2007, *Penedo*-AL).

The dams have changed the characteristics of the river's water. In a thirty-year timeframe, the color of water is more visible now, while the turbidity is low. Staffs of the water treatment plant said, "We saw a reduction in turbidity (suspended sediments). The dams keep them." Now we treat the color and not the turbidity problem to meet drinking water standards. Besides quality issues, the staff expressed concerns in relation to water quantity. Since the water uptake occurs through a fix pipe, change in water level can affect city's water supply if the level of the river falls below the withdrawal zone. The water distribution system has never stopped working, but the treatment system has been impaired. The low level of the water caused the uptake of air instead of water. The city will have to replace it by a mobile system or find another uptake zone in case of a further reduction in the river's water level. Another concern related to priority issues. CHESF controlled the river for its "primary" use, electricity. Then water supply can be compromised especially if the *Transposição* takes place. The quantity of water in the low SFR depends on demand for hydropower usage (Water treatment plant staff, PC, 17 Jan 2007, *Penedo*-AL).

Deforestation, Erosion, Siltation and Navigation

In the 1950s, locals deforested to acquire lumber and charcoal (IBGE 1959). By that time, forests were not an abundant resource (IBGE 1959b). Other forms of vegetated area existed. Farmers used land resting systems, *capoeira*, to protect the soil.[36] Besides wood, the areas provided other environmental services, such as fruits and habitat. The animals that feed on the fruits (e.g., guava trees) spread the seeds for new plants (Fishermen-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). Urban uses and agriculture have contributed to deforestation. Riparian forests in the area are degraded.

[36] *Capoeira* is an area not used for agriculture for a specific period of time to preserve or restore the zone. Plants will grow taller and this fully vegetated area attracts different animal species. This used to be a very common agriculture rotation system in Brazil (IBGE 1960).

Navigation has been part of the city's history. Boats carried people and cargo through the port city which served as the door for the occupation of the valley. In the 1950s, a boat, *Comendador Peixoto*, connected *Penedo* to a town upstream, *Piranhas*. An interviewee remembers using the boats to transport his merchandise from town to town in the lower-SFR (Commerce man who sells coconut-used to be a small farmer, PC, 19 Jan 2007, *Penedo*-AL). Today he still sells products, such as coconuts, but he uses trucks and buses (Commerce man/ex-farmer small farmer, PC, 19 Jan 2007, *Penedo*-AL). Navigation provided jobs for workers, including those involved in loading activities. In addition several boats provided the river crossing service such as the one that linked *Penedo* to *Neópolis* in *Sergipe* (IBGE 1959b).

Navigation in the lower-SFR has not been an easy task. In 1895, British government (1896) reported the danger of the sand bars, impairing navigation from the SFR to the *United States* and *Europe* (British 1896). Pierson (1972, vol.1), in his 1950's study, reported that ocean boats were able to enter the *São Francisco* River from the Atlantic as far as *Penedo*, but sandbars were challenges especially at the river's mouth. The difference is that now, interviewees mention the existence of sandbanks all over the river's extension.

River transports still takes place. In fifteen minutes and with less than a dollar (R$1.50), one can access towns and other states. Passenger diesel boats cross the river many times a day from *Penedo* to *Neópolis* and *Santana do São Francisco* in *Sergipe*. *Propriá* is a more distant destination served by another schedule with boats leaving less often. Ferries are still used to shorten the trip from *Alagoas* to *Sergipe* states, especially due to the bad condition of the road.

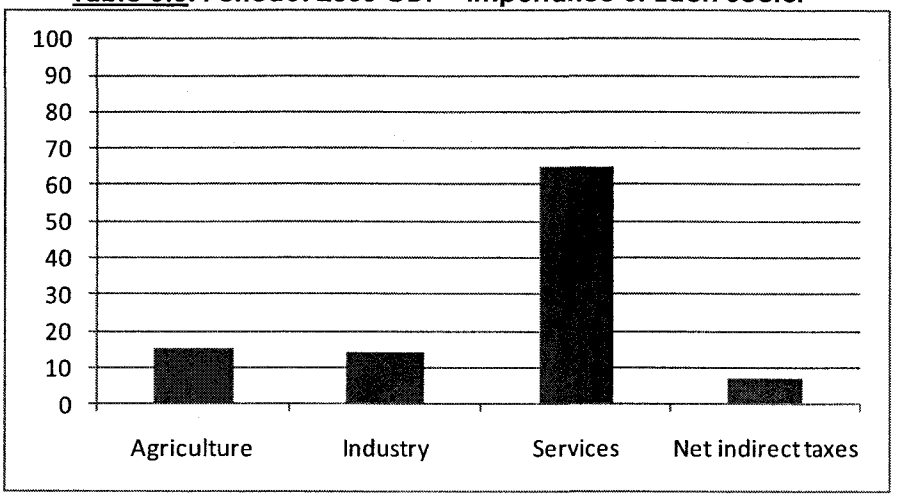
Other Impaired River Uses: Cultural Values, Aesthetical Enjoyment, and Tourism. Navigation was one of the impaired uses. The navigation of large boats has disappeared (Fisherman-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). Areas exist where the river has not been deep enough to submerge a standing individual (Boatman, PC, 16 Jan 2007, *Penedo*-

AL). An interviewee described the river as "a silted pond" allowing only fishermen's vessels and small motor boats (Fisherman and NGO member, PC, 19 Jan 2007, *Penedo*-AL). Navigation used to be easier especially during the natural flood seasons (Ex-rice farmer/today driver, PC, 16 Jan 2007, *Penedo*-AL). Today "even a canoe needs to find its way."

Another local pointed out to me a new indicator to assess change in the lower-SFR, such as the presence of leisure infrastructure now occupying the sandbars. In some towns, the water is so low that in the last five to six years bars (selling food and drinks) have been set up on the sand (Commerce man/ex-farmer, PC, 19 Jan 2007, *Penedo*-AL). The existence of a beach as the "*Prainha*" in *Penedo* is an indicator of profound ecological change.

How developed is *Penedo* Today? In 2007, *Penedo* had 59,020 inhabitants (IBGE 2009a). The Human Development Index of Penedo (0.665) is below the national average (0.766). The low per capita income of the municipality helps to explain the figure low (PNUD 2000a). Service is the most important sector of the economy. It accounted for sixty-five percent of the Gross Domestic Product in 2006 (IBGE 2009a) (Table 6.6 below). *Penedo* is still a city of regional influence that provides services to nearby towns. Some thirty-three percent of the workforce is employed in commercial activities. The municipality centralizes governmental services; about forty percent of the workforce is in governmental institutions (IBGE 2006b). As already mentioned, sugar has replaced other crops. In 2008, the municipality produced 1,221,300 metric tons of sugarcane and only 727 metric tons of rice (IBGE 2009a). This fact also means that irrigated land-use has displaced traditional agriculture.

Table 6.6. *Penedo*: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

Conclusions. The degradation of the environment of the lower-SFR has destroyed both the economic and social basis of local societies which lived primarily from fishing and rice and the accumulation and dissemination of "Traditional Ecological Knowledge" for future generations. [37] The river is still a means of transportation, but it has decreased in importance due to environmental and other changes, such as the construction of dams, the bridge and roads. The Introduction of a new river hydrologic regime, mechanization and irrigation were the causes of ecological and cascading social changes. Local residents' perceptions acknowledge that the river has changed "from good to bad" (Fishermen-CBHSF, PC, 17 Jan 2007, *Penedo*-AL). Despite the ferry which links the two states and brings the outsiders who crosses the river, navigation still serves local cities. Aquatic species were not as rich as before and fishermen barely survive from fishing. The water body was not as alive as it used to be (Commerce man, PC, 16 Jan 2007, *Penedo*-AL).

[37] Traditional Ecological Knowledge as described by Berkes *et al.* (2000).

Shaping the Clay – *Santana do São Francisco* or *Carrapicho* the Little Town Watching Penedo from the other side of the River

Introduction. After a fifteen-minute boat trip from *Penedo* one arrives in *Santana do São Francisco*, the little town located on the west bank of the river. It was important to hear from another perspective, what inhabitants there had to say about environmental changes in that reach of the river. But, in *Penedo*, interviews had already included local people and workers of *Santana*, a town that makes use of another type of resource of the river basin, clay.

My first closer view of the town of *Carrapicho*, as *Santana do São Francisco* is also known, included women washing clothes at the river edge, children playing, and young boys seemingly thirteen of age swimming toward the boat, inquiring about the need for and advertising the service of land transportation (Figure 6.8 below). It was morning and I could see more than a half-dozen donkey carts. Competition makes the boys jump into the water to catch a consumer before arriving in *Carrapicho*. They grasp tight in the window of the boat while soliciting the passengers.

Clothes washing in the waterway was still a common scenario in many cities and towns along the *São Francisco*, such as in *Pirapora* and in *Santana do São Francisco*. Why do people wash clothes in the river if some of them have water delivered to their homes? Many of them seemed to enjoy the companionship of other women: "it is more fun to wash in the river" (Clothes washers, PC, 20 Jan 2007, *Santana*-SE). But here, as well as in *Pirapora*, the local people also revealed their worries about not being able to afford their water bill.

The history of *Santana do São Francisco* goes back to the colonial period. Despite Brazilian colonization by the Portuguese, the Dutch were the first Europeans to inhabit the area. They sought natural resources (e.g., gold and Brasil wood) they were not supposed to exploit. They made everyone believe they were Jesuit missionaries. But,

Portuguese people ended up expelling them. A farm called *Carrapicho* was installed in the region in the beginning of the 20th century (IBGE n.d.a.).

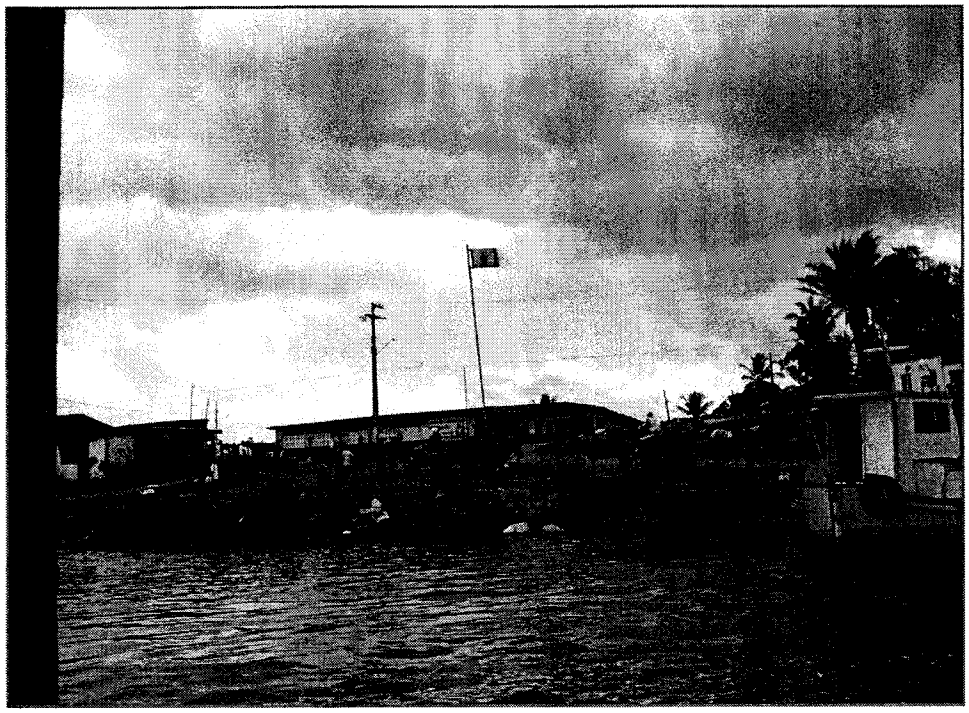


Figure 6.8. Santana do São Francisco
Source: Lucigleide Nascimento 2007.

In early 1950s, most of the pottery from the lower-SFR came from *Santana do São Francisco* (Pierson 1972, vol. 2). The activity employed a large number of the population both man and women who made pottery for domestic use, enjoyment, toys for kids, and religious ceremony (Pierson 1972, vol. 2). The work of other towns could not compete with that of the renowned industry of *Carrapicho* (Araújo 1961). The city supplied neighboring cities of *Sergipe* and *Alagoas*, namely *Penedo* and *Propriá*, and other states such as *Bahia* (Pierson 1972, vol. 2).

Indeed, for a long period the place had been recognized for its pottery initially constructed to meet the household needs of farm employees. Already in 1859 the journal of the Instituto Histórico e Geográfico Brasileiro cited the two clay manufacturing sites which existed in the village (IHGB 1859). The pottery became an important economic

and cultural activity for the region. It is now known nationwide. But, similarly to other parts of the lower-*São Francisco*, rice has been an important agricultural product (IBGE n.d.a.) as were fishing and navigation.

The town of *Santana do São Francisco* has only been an independent municipality since 1991 [EC Sergipe # 2, Art.1, 1990]. *Santana* is located at 124 kms in a straight line and by roads from the state capital. It is only 46 sq. kms large, and a broad area of the municipality stands on high ground. It is twenty-five meters above the sea level (Sergipe 2001b, Bomfim 2002a, IBGE 2009a). It overlooks *Penedo*. Those born in *Carrapicho* are *Santanenses*. In the 1950s, there were 1,400 inhabitants living in the urban zone of *Carrapicho* (IBGE 1959c).

The River Environment. The climate is dry and sub-humid. The average temperature was of about 79° F and the annual precipitation level was 47 inches (Bomfim 2002a). The valley's boundaries integrally included the town. The Atlantic Rainforest is *Santana do São Francisco*'s biome.

A local fishermen and potter said that, in the past, fishing was the major survival strategy of his and many families. Now the top position had been replaced by the manufacture of pottery (Fisherman and potter, PC, 20 Jan 2007, *Santana*-SE; SEBRAE 2008). The town still has two areas of industrial extraction of clay (CPRM 2010). Most of the clay is removed from such deposits in the inland lagoons. But locals also remove it from riparian zones (Sergipe 2003b). The donkey carts have carried the clay and wood to potter and to their ovens throughout the town.

But the two activities, fishing and pottery making are seasonal and in some cases complementary. The sale of handcrafts takes place mostly during six months of the year, with January being the most important one. It is probably because it is a vacation period in Brazil and the number of tourists is high. Other forms of employment have existed in town: local government; agriculture as a business; and family based agriculture with

locals growing corn, bean, manioc, cabbage, lettuce, and tomatoes. Transportation has been another service activity employing boats or donkey carts that also have carried the cargo that crosses the river by boats. As an interviewee said, "I receive the clay which comes on the back of the animals" (Fisherman and potter, PC, 20 Jan 2007, *Santana*-SE).

Causes of Environmental Degradation. The major causes of environmental degradation in the area were related to the existence and operation of dams: lack of periodical flooding and low water. But, as with other municipalities, water pollution was an issue of concern. Rudimentary methods of dealing with sewage (cesspit) and septic systems were the waste management practices (Bomfim 2002a). But, some 88% of the population of the urban area have improved septic systems or are linked to the city's network (IBGE 2000b). But, a sewage treatment station did not exist in *Santana do São Francisco*. It is possible to see sewage flowing in open pits and creeks (IBGE 2005b). But the Integration Ministry developed the project for the sanitation of the town as part of the Revitalization program (MIN 2004b). The local government collected refuse and garbage from 87% of the homes in the town and disposes them in municipal lands spread on the landscape (IBGE 2005b, Bomfim 2002a).

Agriculture and Other Non-Point Source of Pollution. The expansion of agriculture had affected water bodies, as for example eroding its riparian zones (IBGE 2005b).

The Fishery. Change in hydrological regime and silting of water bodies had reduced the quantity and diversity of fish species (IBGE 2005b).

Other Ecosystem Services. The state energy company, *Empresa Energética de Sergipe* – ENERGIPE supplied the town's electricity (Bomfim 2002a).

Water Supply. The state water management company, *Companhia de Saneamento de Sergipe* – DESO managed the two wells for public water supply (Bomfim

2002a). In the urban zone, about 93.2% of the homes were linked to the city's network (IBGE 2000b).

Deforestation, Erosion, Siltation and Navigation. Water management for irrigation and hydropower purpose changed river's channel, destabilized banks and increased erosion in the lower-*São Francisco* (Holanda *et al.* 2005). The locals worried about the present and future state of the river. "We will be able to cross the river to the city of *Penedo* by foot" (Small-farmer, PC, 20 Janeiro 2007, *Santana*-SE). They also remembered the days when large ships used to navigate the waters of the *Velho Chico*. Today it is hard for larger motor boats to maneuver. The waterway is a "creek," sometimes full of sand (Small-farmer, PC, 20 Janeiro 2007, *Santana*-SE).

Deforestation was also a problem (IBGE 2005b). Land use and change for agriculture and livestock, extraction of wood and mineral resources, fire, and road construction have deforested riparian and inland areas. Indeed, riparian vegetation now covers only 4% of the river's edges in the lower-SFR (Holanda *et al.* 2005, 328). In addition, pottery requires wood for the firing process.

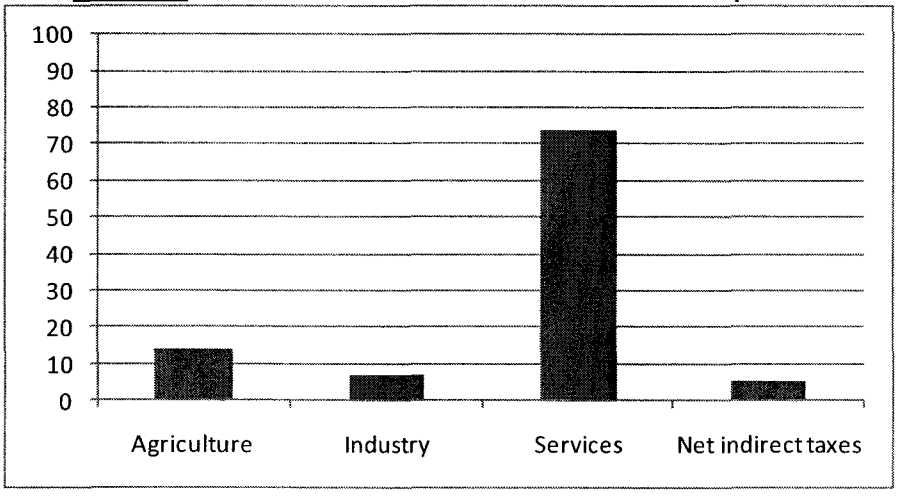
Other Impaired River Uses: Cultural Values, Aesthetic Enjoyment, and Tourism. The use of the river has been impaired for traditional economic and social uses, such as for agriculture in lagoons and fishing. No other observations were found.

How developed is *Carrapicho* Today? In 2007, the town had 6,596 inhabitants (IBGE 2009a). The Human Development Index of *Santana do São Francisco* (0.579) is significantly below the national figure (0.766) (PNUD 2000a). The low income of the municipality reduces the HDI number.

In 2006, agriculture accounted for 14% and services for 74% of the Gross Domestic Service (IBGE 2009a) (Table 6.7 below). The municipality partially includes a joint state-private irrigation project, *Platô de Neópolis*. The zone produces among other fruits, coconut, citrus and bananas (Sergipe 2008, Mota 2000, Cavalcanti *et al.* 2006).

Carrapicho also embraces irrigation projects that CODEVASF implemented in the 1970s (Cavalcanti *et al.* 2006). Sugar-cane, rice, manioc and mango complement *Carrapichos*'s list of agricultural products. The *São Francisco* and wells supply water for agriculture (Bomfim 2002a). In 2008, *Santana* produced 780 metric tons of sugarcane and 35 metric tons of rice. It is an important grower of cassava, producing 1,440 metric tons in 2008 (IBGE 2009a). Cattle ranching, chickens raising, and clay mining are other income-generating activities (Bomfim 2002a). Some six percent of the workforce is employed in agriculture (IBGE 2006b). The other two major activities of the town do not show up in statistics because they are part of the informal labor sector: pottery and fishing. Estimates suggest that 480 artisans produce 432 thousand clay pieces per month. Arts and crafts activities employ about seventy percent of the local work force (SEBRAE 2008).

Table 6.7. *Santana do São Francisco*: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

The decline in river fishing had led people to seek out other survival strategies. Aquaculture was one of the economic activities of the region undertaken by producers' associations (Sergipe 2008). In 2003, an association produced 4.8 tons of fish (MMA-

IBAMA 2004). As a boat man said, "fishermen are raising their own food, the fish" (Boatman, PC, Jan 16, 2007, *Penedo*-AL).

Other social changes had influenced local populations of the lower-SFR. Governmental hydropower projects had modified the social order which consisted of small-scale landless farmers working in seasonally flooded riparian lagoons in partnership with large landowners. Irrigation projects sought to address the environmental changes, such as the lack of periodical flooding and change in the area inundated. Those irrigated schemes only benefited one-third of the ones who needed land (Cavalcanti *et al.* 2006). In addition, in the initial phase, the projects introduced machinery and reduced the number of workers.

Conclusions. *Santana do São Francisco* is another example of the shift from a traditional existence towards the hydro-businesses model. Notwithstanding being in the other side of the river, the problems created by the dams are similar to those in *Penedo*. But the unique characteristic of this place was the clay element and how local residents sought their survival from the earth. It was difficult to make any precise statement on the importance of fishing and clay without official statistics. It was impossible to know how many individuals have been employed in the pottery business over time. But, an educated guess suggested that the number of individuals in that activity has increased with the decline of fishing and traditional agriculture in the region.

The Big Swamp: *Brejo Grande*

Introduction. The narrow main street of *Brejo Grande* takes a visitor on a trip through time. One row of colorful residences stands parallel on each side of the paved stone road. Red tile roofs and one-floor dwellings are the norm. Some owners have elevated their homes on concrete pilings in order to protect their life investment. Unexpected floods could turn the land into a *Brejo Grande*, a big swamp. During such

events, locals reported, it was possible to fish in the street. Old cars, bicycles, even a cattle herd crossing the road carried me to a distant past. Satellite dishes on house roofs were the time machine in-charge of transporting me back to the present. Coconut and other fruit trees completed the background under a radiant blue sky (Figure 6.9 below).

Figure 6.9. *Brejo Grande*: Uses of the River
Source: Lucigleide Nascimento 2007

Research and field work in the basin have opened my eyes to the difficult task of isolating variables in the real world. Many experiences have reshaped the local environment, such as urbanization and the link with outside worlds. I thought that a more geographically isolated place would have maintained a closer link with the river and a smaller degree of interference. The Big Swamp is located as downstream *São Francisco* as it is possible to go. An encounter in *Brasília*, at a protest camp, with a young fellow engaged in the protection of the *São Francisco* River made me think about visiting the place.

Another important factor influencing my decision to visit *Brejo Grande* was that the municipality was composed of villages with peculiar environmental and social history. *Cabeço* was entirely washed out by the Atlantic Ocean. *Brejão dos Negros* was a small village, whose part of the population struggled for recognition of its status as a *Quilombola* community, a place established by escaped slaves (maroon).[38] In addition, a disease destroyed an important survival strategy of *Brejo Grande* region, crab collection. This section will focus on *Brejo Grande* in general and on *Cabeço* and *Brejão* villages because of their environmental accounts.

Brejo Grande, also known as *Parapitinga*, became a town in 1926 (CODEVASF 2001). The municipality is 150 sq. kms large (IBGE 2009a). It is 83 kms far from the state capital of *Aracaju* in a straight line (Sergipe 2001b), and 137 kms by road (Bomfim 2002). The district was located at 6 meters above the sea level (Sergipe 2001b). *Brejo-grandenses* are the ones born there.

In the 1950s, some 10,732 individuals inhabited the municipality of *Brejo Grande*. About 2,000 lived in the municipality's district. Some 2,500 people resided in *Brejão* and between 400 and 500 individuals in *Cabeço*. Agriculture and cattle raising were the two major economic activities of the region in terms of employment. Rice lagoons, coconut groves and other fruit orchards comprised the local agriculture (retired boat worker, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE). Rice was already important, and coconut groves were in an expansive phase. Producers added 10 thousand new palm trees to the area in the 1950s. In 1956, local fishermen caught about 400 tons of fish from freshwater and from the ocean. Manufacture included rice and manioc processing facilities and salt extraction. Commerce consisted of small stores (IBGE 1959d). In 1956, *Brejo Grande* produced about 800 tons of salt (IBGE 1959d).

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[38] A federal government foundation, *Fundação Cultural Palmares* has now certified the area's heritage (Sergipe 2009).

The waterway means various things for the *Brejo-grandenses*. For them the river is life (Religious figure, PC, 05 Jun 2007, *Brejo Grande*-SE); it means everything (NGO representative, PC, 05 Jun 2007, *Brejo Grande*-SE). The river is the most important thing after God (Fisherwoman and fisherman, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE). It has supported most of the families of the region who made a living from activities such as fishing, rice and pasture fields in the lower river (Religious figure, PC, 05 Jun 2007, *Brejo Grande*-SE). Local residents also collected crabs and shrimp from the estuary (Crab collector, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE).

The River Environment. The climate is humid and semi-humid in *Brejo Grande*'s Atlantic Rainforest biome (Alves *et al.* 2007). The average temperature and annual rainfall were respectively 79° F and 47 inches (Bomfim 2002b). The area had benefited from the presence of riverine, marine and estuarine environments. Along with smaller ones, a big fluvial island, *Arambipe* located at the mouth of the river (Azevedo 1968, vol. 1). The *Velho Chico and its* arms and legs, as *Brejo-grandenses* described its creeks, penetrate the village of *Brejão dos Negros* and flood lagoons (Crab collector, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE). "[T]he water level of the lower *São Francisco* near by the coast is high during local drought season, and low in its local rainy season" (Pierson 1972, vol. 1). The reason is that, most of the *Velho Chico*'s flow comes from the distant *Minas Gerais*. In addition, management of hydropower infrastructures changed the river here too. In the past locals knew the period of waters: rainy season, high river water and elevated sea's water. But, *Sobradinho* and other dams changed the flow. The ones living in *Brejo Grande* used the lagoons for both growing rice and catching fish. They cultivated the lagoons from their borders to its center. The center of the lagoon kept water and aquatic species (Sergipe 1972).

Causes of Environmental Degradation. Local residents recognized that the river needs to be taken care of (rice plantation worker and small farmer, PC, 04 Jun 2007,

Brejão- Brejo Grande-SE). They observed the deteriorating condition of the SF. Some even believe that the river is dying (Fisherwoman and fisherman's wife, PC, 07 Jun 2007, *Cabeço-Brejo Grande*-SE). Similar to other municipalities of the lower-river, *Brejo Grande* suffered the consequences of the sequence of dams. The control of flooding in the lower-river was not a surprise. It was an envisaged outcome. The management of inundations and improvement of agricultural exploitation of flooded areas in the lower-river was even part of *Três Marias* program (Serebrenick 1961).

Since the beginning of the twentieth century, an endless conflict between the river and the sea took place at SFR's mouth (Branner 1904). The volume of water was high and swept the river's silt into the ocean. This fact did not eliminate the creation of islands and sandbanks near the SFR's mouth (Pierson 1972, vol.1). An interviewee from the town of *Carrapicho* asserted that, in the past the river's current was so strong that it was able to carry sand into the sea (Small farmer, PC, 20 Jan 2007, Lower-SFR, *Santana do São Francisco*- SE).

Pierson (1972, vol.1) suggested that the river in fact carried sediments into the sea due to the high volume of the river's water. The volume of sediment rich freshwater inhibited coral formation in the area. The waters of the SF used to be recognized in the Atlantic by their color. Mud deposited further into the sea. In the 1950s, the waters of the SFR were still penetrating out distances into the Atlantic Ocean, but its strength had already been reduced (Pierson 1972, vol. 1).

But, local residents and the literature have mentioned a change in the river's volume and in the strength of its current. Today the water is without the "vitamin" as a resident from *Brejão dos Negros* expressed it. The dams hold back water and sediment (Retired boat worker, interview, 04 Jun2007, *Brejão-Brejo Grande*-SE). When the water leaves the reservoirs, it is "hungry water." The sediment-starved flow sculpts the landscape, eroding, transporting and depositing sediment (Kondolf 1997). At the river's

mouth as the load of sediments is reduced, sea waves accelerate beach erosion (Kondolf 1997, Bittencourt *et al.* 2007). As a result of the decrease in water and sediment discharge at the mouth of the *Velho Chico* the small oceanside village of *Cabeço* has been completely washed out to sea. Similar effects occurred at nearby village of *Costinha*. Indeed, the lower-SFR region is affected by the Atlantic Ocean tides more today than before the1950s.

A lighthouse originally built about 280 meters from the ocean in the village of *Cabeço* barely stands at a site that used to be in town in 2007(Bittencourt *et al.* 2007). The village needed to be rebuilt in another district, *Saramém*. But, some of its residents decided to stay in the village, moving it to higher ground. It has been quite a transformation from the past when Halfeld (1860) predicted that the sand carried by the water would move the sandbars of the SFR into the sea.

Change in water and sediment flow was causing other problems. The river was full of *Rabo-de-raposa* and *Cabelo algae* (Fisherman/apiarist/rice plantation worker, PC, Jun 06, 2007, *Brejão-Brejo Grande*-SE). The transparent water, without the sediment kept by the dams, allowed the development of these algae (CODEVASF 2003). Another problem that affected *São Francisco* River's species was the change in salinity. Local residents found salt water shellfish species where they used not to be (Pierson 1972, vol. 2; Fisherwomen/ fishermen association, PC, 07 Jun 2007, *Brejo Grande*-SE). Local people complained about the destruction of the shrimp bank (stock) (*banco do camarão*), the shrimp habitat and population in the mouth of the river (CODEVASF 2003).

In addition to the quantity, the quality of the water was an issue too, and local municipalities contributed to the problem. Rudimentary (cesspit) and improved septic systems were the sewage treatment systems of *Brejo Grande* (Bomfim 2002b). But, only 2% of the homes in the urban zone has access to improved septic system or are linked to

any type of town's network (IBGE 2000b). A sewage treatment plant did not exist *in Brejo Grande* (WTP staff, PC, 05 Jun 2007, *Brejo Grande*-SE).

The local government collected garbage and refuses from 68% of homes in town and disposes them in an open area (Bomfim 2002b, IBGE 2009b). Burning part of the waste was the only form of management that took place (IBGE 2005b). In 2005, some 1,092 homes had a bathroom, 3 were linked to the general sewage system and 521 did not have indoor plumbing (Sergipe 2005).

Agriculture and Other Non-Point Source of Pollution. In the 1950s, the seasonal floods inundated and fertilized riparian zones favoring rice growth in the lower-SFR (IBGE 1959d). Rice plantation depended directly and indirectly on the river and on the sea tides. In *Brejo Grande*, the rise of sea also made the *São Francisco*'s waters reach higher ground throughout its lower tributaries, the *Paraúna* and the *Parapuca*. In 1968, *Brejo Grande* had the second highest production of rice and coconut (in value) of the lower-SFR in the state of *Sergipe*. The state exported rice to *Recife*, *Aracaju*, *Maceió* and *João Pessoa*. A fact which gave an idea of the magnitude of production was that the lower-SFR in Sergipe accounted for ninety percent of the state's rice output (Sergipe 1972). It employed a large share of the population, in a more labor-intensive approach especially in the preparation of seedling, in the system of sharecropping, in areas from 50 to 500 ha (Sergipe 1972).

Brejo Grande produced rice, coconut, mangoes and manioc (Bomfim 2002b). In 2004, in *Brejo Grande*, 8,225 tons of rice grew in 2,500 ha of land almost twice the area and three and a half times the total produced on average between 1967 and 1969 (Sergipe 2005, Sergipe 1972). The 2006 livestock census showed that *Brejo Grande* had 3,177 cattle, as well as horses, sheep and pigs (Bomfim 2002). Animal raising and the use of fertilizers were known sources of pollution in the municipality (IBGE 2005b).

The Fishery. Aquatic species abounded in the past especially after floods. As asserted by a religious figure, "an impressive poverty of fish exists today in the *São Francisco* River (Religious figure1, PC, Jun 05 2007, *Brejo Grande*-SE). In *Brejão dos Negros* and in the district of *Brejo Grande*, locals collected crabs from the mangrove, fish and catch a small shrimp, *saburica* (Fisherwoman/ member of fishermen association, PC, 07 Jun 2007, *Brejo Grande*-SE; crab collector, PC, 06 Jun, 2007, *Brejão-Brejo Grande*-SE; fisherwoman/fisherman, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE).But, it had changed from the past when they used to catch buckets full of shrimp. In 2007, they already caught much less (Crab collector, PC, 06 Jun 2007, *Brejo Grande*-SE). The *São Francisco* and its "arms" also brought less fish and shrimp. The *Velho Chico* together with the sea, create the mangrove for crabs.

Others Ecosystem Services. In the 1950s, in *Brejo Grande*, diesel engines generators provided the energy for the public supply of only 80 homes (IBGE 1959d). *Brejo Grande* started to receive the power from the SF in 1968 (CHESF 1970). Now, *Empresa Energética de Sergipe* – Energipe distribute the electricity CHESF produces.

Water Supply. Rivers and wells provided water to the municipality. The 2000 federal census showed that 80.3% of the homes in the municipality are linked to a public water supply system (IBGE 2000b). In *Brejo Grande* district, the water was disinfected and received fluoride. The only tests made locally were for chlorine and pH. People complained about the taste of the water, specifically its level of salinity, and for that reason many prefer to collect water directly from the river. Others did the same for other reasons. A cemetery was located next to the water treatment plant. A plant's staff assured that the source well was located 500 meters from the water treatment station. But, locals did not seem to believe this (WTP staff, PC, 05 Jun 2007, *Brejo Grande*-SE).

In *Brejão dos Negros*, an approximately twenty-year old well supplied the city. The staff tested the water for pH, iron and chlorine. Once a week, tests were made in the

state's capital, *Aracaju*. The *São Francisco* had been thought as a direct water source. Measurements had been undertaken, but the water still came from well (WTP staff, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE).

In *Brejão*, local residents assured that the water was not good for drinking. "If you let the water sit in a bottle overnight, we are able to see the dirt on its bottom" (Crab collector, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE). *Brejão* and *Brejo Grande*'s WTPs look old and run-down. The high level of iron is visible in the area. In *Brejão* one saw it in the WTP's environment and the in the water which ran through the station's filters.

Deforestation, Erosion, Siltation and Navigation. In the 1950s, the area was not rich in trees, except mangroves (IBGE 1959d). The land was used for cattle and agriculture and fruit groves. By 2007, deforestation and landfill still took place and environmentally and aesthetically impacted the area (IBGE 2005d, Alves *et al.* 2007).

In the 1950s, only the river linked the town to the outside world (IBGE 1959d). Besides the sea winds pushing the sailboats upriver during daytime, boat workers could count on steamers and later on diesel boats (Baity 1951) (Retired boat worker, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE). For example, from *Brejão dos Negros* to *Penedo* a boatman used his sail boats (e.g., *canoa de tolda* and *chata*) to carry wood, rice, coconut and mat made of woven grass (*junco*). As explained in the section for *Penedo*, in the lower-SFR, women made and locals used mats for various purposes (Pierson 1972, vol. 2). The vital produce, rice left the general region via *Penedo*'s port (James 1953). Rice from the lower-SFR supplied markets in the southern region and various capitals of Brazil (SUVALE 1968a). In general terms, the boats of the lower-SFR carried rice and fruits (e.g., *mangaba*, mango and coconut) upstream and transported downstream tiles and bricks, beans, and the fruit *umbus*. (NGO representative, PC, 05 Jun 2007, *Brejo Grande*-SE). They supplied the local commerce (Retired boat worker, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE).

The transportation system worked in the following way:

> The passengers used to arrive in *Piaçabuçu* [on the opposite side of the river]: people from *Sergipe*, people from *Alagoas*... They used to go from there to *Penedo* by boat. Two diesel boats aided the navigation. (Retired boat worker, PC, Jun 04, 2007, *Brejão-Brejo Grande*-SE)

Besides competing forms of transportation which reduced the importance of river navigation, the low level of the water exposed the bottom of the river and sandbanks impairing navigation.

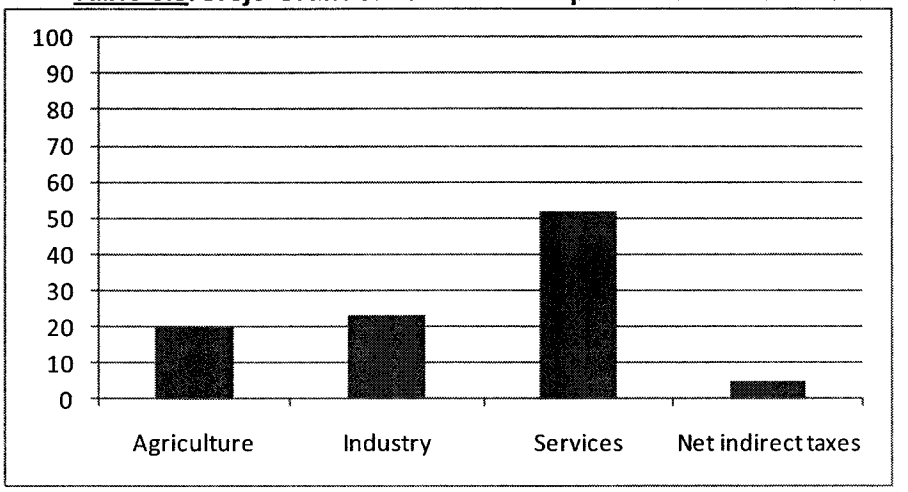
Other Impaired River Uses: Cultural Values, Aesthetic Enjoyment, and Tourism. The *Velho Chico* in *Brejo Grande* was still a means of transportation. A barge links the town to *Piaçabuçu*, a municipality in *Alagoas* next to *Penedo*, also in the SFR's mouth (NGO representative, PC, 05 Jun 2007, *Brejo Grande*-SE). Smaller boats were the means of transportation for the locals, such as fishermen. On average, three buses arrived and left daily for the state capital, *Aracaju*, reducing somewhat the level of the town's isolation. I took that route for *Brejo Grande*. During tourist season, extra buses and cars bring visitors to town on their way to the mouth of the river. The river is still a meeting place for local residents, as for example, women wash clothes, kitchen wares and bathe their kids.

How developed is *Brejo Grande* Today? In 2007, 7,760 individuals inhabited *Brejo Grande* (IBGE 2009a). This town is the only one among the municipalities studied that exhibited a decrease in population. The number for 1950s was of 10, 732 (IBGE 1959d). But, it is important to mention that, besides out-migration, a village which become an independent municipality, *Ilha das Flores*, decreased the official population of *Brejo Grande*.

Agriculture accounted for 20%, industry 23% and services 52% of the gross domestic product (IBGE 2009a) (Table 6.8 below). In 2008, *Brejo Grande* produced 6,000 thousand coconuts in an area of 3,000 hectares, 922 metric tons of mangoes, 8,400 metric tons of rice and 1,760 metric tons of cassava (IBGE 2009a). Rice is still the major

agricultural product but it does not employ as many due to the introduction of mechanization. In 2007, the municipality had a herd of 3,725 cattle (IBGE 2009a).

Table 6.8. Brejo Grande: 2006 GDP - Importance of Each Sector



Source of data: IBGE 2009a

Many complained about the lack of opportunities in the region. Only 389 people were officially employed out of a population of a little over 7 thousand (IBGE 2009a). As an interviewee said, "Jobs do not exist in the town, only the income from the retirees" (Clothes and dishes washer, PC, 05 Jun 2007, *Brejo Grande*-SE). Younger generations also survived from federal government's poverty alleviation programs (e.g., *Bolsa Escola, Bolsa Família*). The ones with differentiated skills undertook specialized work in the region, such as tending the coconut plantations and lagoons' walls that crabs usually destroy and received pay per day of labor or per service (NGO representative, PC, 05 Jun 2007, *Brejo Grande*-SE). As a consequence, many have opted for fishing in a period of time when other stresses have affected the resource.

Brejo Grande was one of the poorest areas of the state of *Sergipe* (Religious figure, PC, Jun 05, 2007, *Brejo Grande*-SE). The Human Development Index is substantially below (0.55) the national average (0.766) (PNUD 2000a). It was the lowest among the seven municipalities studied, followed by *Santana do São Francisco* (0.579) (PNUD

2000a). Besides the low income, the life expectancy in Brejo Grande was very low too (PNUD 2000a).

Other factors had influenced the socio-economic dynamic of the region. Mechanized rice plantations replaced traditional techniques and forms of labor relations. It was common in the past to find sharecropping in rice fields and temporary permits to cultivate small plots of land in exchange for work in coconut groves, which required more effort during the orchard implementation phase. Rice planting used to be more labor intensive and employed many. Indeed, in early 1970s, sharecroppers and their family members formed the larger share of the workforce employed in agricultural activity in the lower-SFR in *Sergipe* state (Sergipe 1972).

Land concentration was already a problem in the 1950s (IBGE 1959d). Landowners had also restricted the use of their domain due to raising land right issues.[39] The context involved new users and uses. For example, a construction company, Narcon bought land in the area which included lagoon areas, planning to build a tourist resort. This eliminated local access to the resource impairing the traditional use.

Petroleum was another source of income for *Brejo Grande*. *Petrobras*, the Brazilian Petroleum Company, and a concessioner, Silver Marlin E&P de Petróleo e Gás Ltda exploited the resource in the region (Siqueira 2009, ANP 2009). Silver Marlin reactivated a small-scale oil reserve that Petrobras had operated from 1983 to 1998 (ANP 2005). The municipality received royalties and services fees for the exploitation of this natural resource (Santos Jr. 2006). The area included pipelines to transport the petroleum. Leaking was a potential threat to local ecosystems. Marine salt remained another form of mineral extraction of the region (Alves *et al.* 2007).

The municipality hosted aquaculture businesses, namely fish and shrimp farming. Local residents believed that aquaculture (shrimp farming) brought crab disease to the

[39] *Usucapião* means that after specified years the user of the land has the right to claim judicially its ownership.

region.[40] The illness destroyed one of the pillars which support the local economy. According to the head of the crab collectors association, before the disease hit the town, 90% of *Brejão dos Negros* depended on both crab collection and fishing. Experienced collectors who used to catch 210 crabs a day, four years later catch not more than half that number, and sometimes only a few. Dead crabs brought a bad odor to the swamps. *Universidade Federal do Paraná*'s studies showed that a fungi species, *Exophiala psychrophila*, caused the disease (Boeger *et al.* 2006). But local residents believed that, chemical products used on shrimp farms were responsible. According to residents, the same product also killed ticks on horses washed with the river's water. The disease killed various species of crabs (e.g., *siri)* and freshwater shrimps (e.g., *aratu*). In 2007, it was still killing crabs, but fewer (Crab collector, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE).

Conclusions. In *Brejo Grande*, the water body which was once the only contact with the outside world today cannot maintain the consequences of the external transformations away from its people and villages. New activities include tourism and related services such as food preparation. Coconut groves still provide employment. But, with the grove well established, it does not require as many workers as in its initial phase. Rice cultivation is mechanized. Subsistence crops are grown on fewer small plots and rice fields still depend on rainfall and on the tidal movement of the *São Francisco* River.

Summary and Transition to Next Chapter

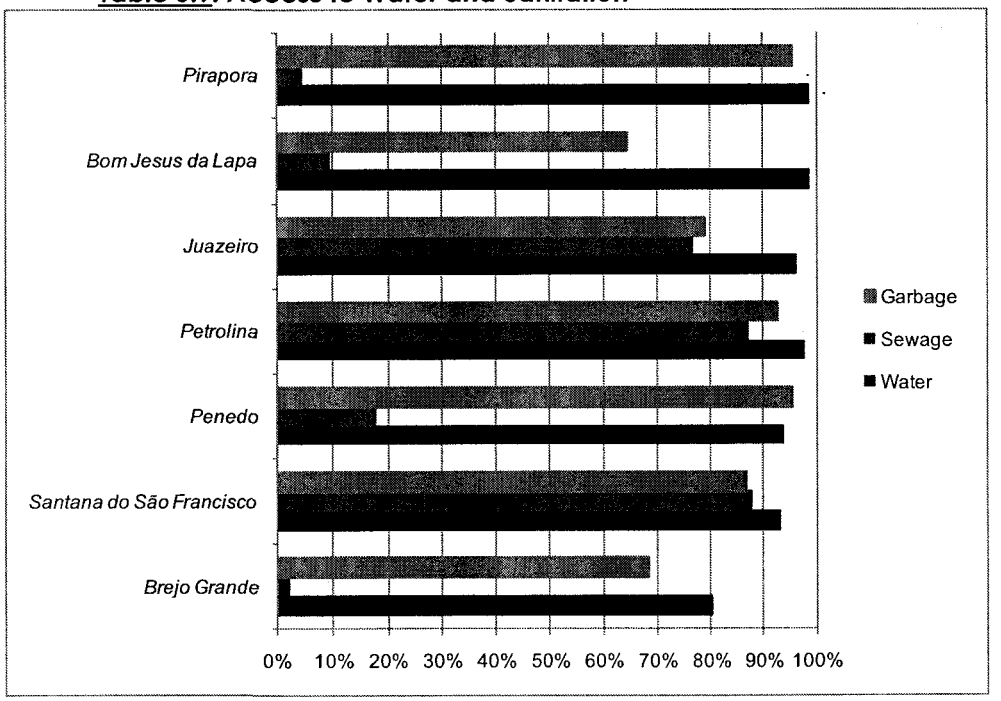
In previous assessments of towns and cities of the valley, authors (Valverde 1944b, Baity 1951, IBGE 1959d, Duarte 1971, Pierson 1972) observed the almost complete absence of garbage and sewage collection and treatment, and of public water supply services. Garbage was left on the surface of the ground without any form of disposal,

[40] Other conflicts exist regarding crabs. Local residents affirm that the crabs open holes and destroy rice's lagoons walls. Rice growers do not like crabs.

except open burning. Sewage simply flowed into water bodies. Users collected water directly from the river or from water fountains, or paid water carriers to do so. Given the level of necessity, the policy implemented can been seen as an improvement, such as the implementation of autonomous water treatment stations and the digging wells, even knowing that the number of stations and wells was unable to supply all homes in town.

As observed in this chapter, all municipalities studied now have a high percentage of population linked to the water supply systems. The municipality is not in charge of granting water use rights for the *São Francisco* River. It has no control over the resource.

Table 6.9. Access to Water and Sanitation



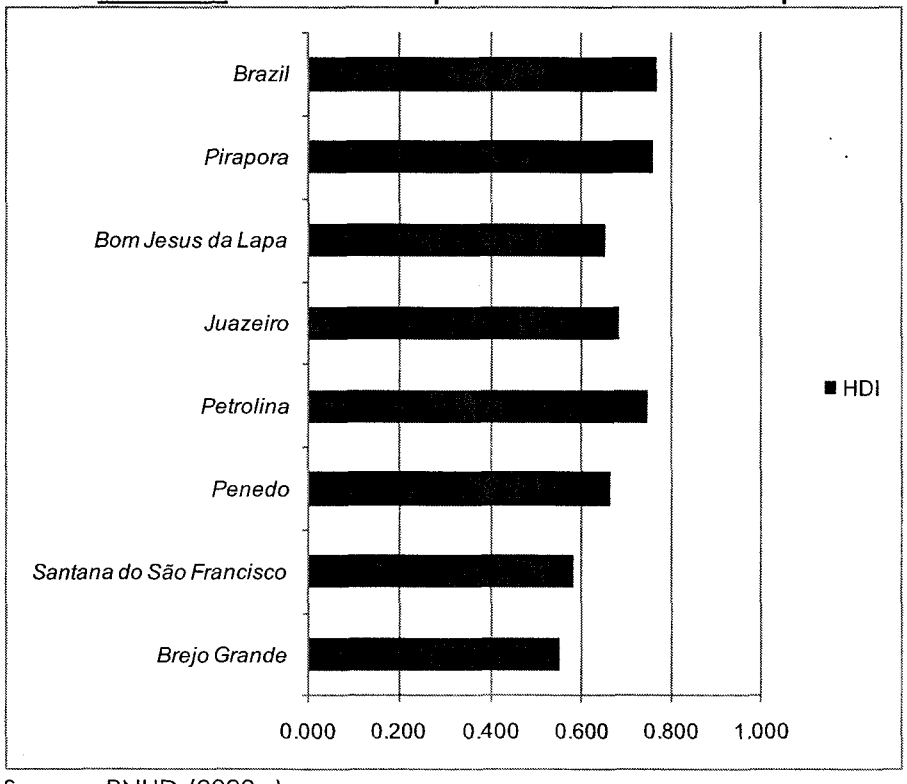
Source: IBGE (2000)

The seven places are deficient regarding the treatment of their waste. Water pollution is one of the major contributions of municipalities to the environmental decline of the river. At the local level, municipalities can work on avoiding raw sewage discharged into the river and reducing the amount of garbage that reaches the river. The Table 6.9 below shows the shockingly low percentage regarding access to sewage

treatment or improved septic systems for the seven municipalities, except for *Santana do São Francisco* which has been improving it. Another source of contamination is land use, mainly agriculture, a source not easy to manage. Municipalities can control land uses by zoning, but have no say over federal government decisions on building hydropower or large-scale irrigation projects.

The Table 6.10 below compares the Human Development Index of each municipality with the figure for Brazil. All seven cases present numbers below the national average. But *Pirapora* and *Petrolina* are only slightly off from the Brazilian HDI.

Table 6.10. Human Development Index: Seven Municipalities and Brazil



Source: PNUD (2000a)

This chapter introduced the reader to the seven municipalities presenting the particularities of each place, "orienting the problem." The next chapter contrasts the results of the environmental changes across-cases. It also provides the findings and discussion regarding public participation and the governance system for the basin.

CHAPTER VII

EVALUATION: FINDINGS AND DISCUSSION

This chapter reports on the extent to which the case studies met the criteria for policy effectiveness toward ecosystem-based management. Three sets of findings-and-discussion compose this Evaluation. The first one relates to the major research question: **what have been the impacts of the federal water resource management, or lack of it, on the riverine environment and on the life of the people who locally depended on river's services from 1940s to 2008?** It assesses sustainability of the river employing indicators of threats to the health and integrity of the freshwater system and changes in ecosystem services. It examines causes and environmental consequences of the river's present state linking them to socio-economic costs. Finally it shows how those effects have affected the specific stretches of the watercourse.

This section compares the case studies to enable a local and closer view, and to capture a holistic understanding of cumulative effects of individual problems upon this river system. This research methodology does not allow generalization, though I note similarities in trends along the river, commonalities among the sites. It is important to point out that some interviewees go beyond perceiving the environmental problems as a "Not in My Back Yard" – NIMBY issue, approaching them with a holistic view. For example, one interviewee said: "There is not only one more affected area... as a whole... as a sick being... the entire organism is sick... and requires attention" (Religious figure, PC-phone interview, 13 Jan 2007, *Barra*-BA).[1] This section also shows how the uses of the ecosystem

[1] PC means Personal Communication.

services of the SFR have changed throughout the timeframe studied and how meanings and uses have been impaired, but also have improved other applications of the water body.

The second and third sets of findings-and-discussion deal with my second research question: **how does the new approach to water resources governance, endorsed by the Water Policy # 9,433 of January 08, 1997, promoted in the *São Francisco* River Basin by its respective watershed-based management committee, the *São Francisco* River Basin Committee (CBHSF), differ from old forms of governance regarding public participation and the achievement of its intended goals, such as sustainability, and to what extent is it succeeding?** The second set appraises the role different sectors of the society now play in the management of the water resources of the *São Francisco*. Legally mandated public participation in water resources management was non-existent almost for the totality of the timeframe of this study. It was required in 1997 by the new prescription, the Law# 9,433 – the Water Policy.

The last set evaluates the effectiveness of the new governance system. It also shows how it differs from the form used in the past regarding both goals and achievements. It points to the similarities between the new approach and ecosystem-based management.

Findings-and-Discussion: Assessing Sustainability using the Indicators of Damage and Change in Ecosystem Services – Cross-case Analysis

Changes, Causes and Environmental Consequences

In 1950, Baity (1951, 159) described the existing paradigm, the "inequity of Nature," through a nation's saying: "under natural conditions nothing is ever just right: it is always too big or too little, too steep or too flat, too hot or too cold, too wet or too dry." Transformation of nature and development of natural resources to serve human needs

were the views of that time. An imperfect nature provided the means for progress.[2] But, the Brazilian journey toward 'perfection' has negatively impacted the *Velho Chico*, as portrayed by the environmental history of the basin and municipalities studied described in Chapter II. Problem Orientation I and Chapter VI. Problem Orientation II. The two chapters identified signs of degradation of the SFR ecosystem over time using data from observations, interviews, and literature review. The Chapter II provided a general view of the system, and Chapter VI the particularities of selected municipalities.

Sustainability of the SFR system is viewed as a dynamic state of balance, a condition different from the river the local people described during my fieldwork. The Table 7.1 below is a checklist of indicators of damage, grouped into categories, as the interviewees perceived the changes on the condition of "their" river and reported during the time of the interviews for the period between Aug 2006 and July 2007. The Figure 7.1 below shows the seven municipalities and the location of the dams in the *São Francisco*.

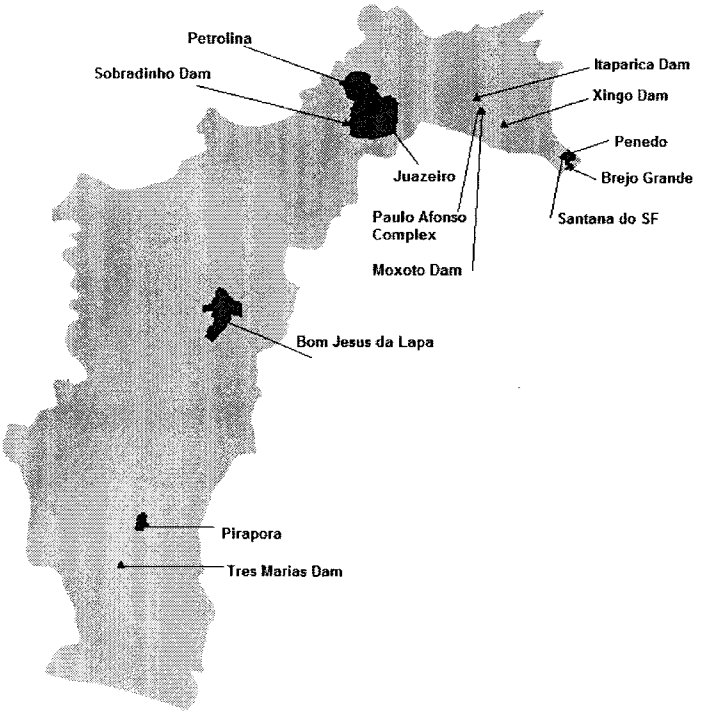


Figure 7.1. The Seven Municipalities Studied and the Dams.
Source: derived from geo-referenced data from ANA Hydroweb visited on 03 September 2009 (ANA 2009).

[2] Hirschman (1963) described part of that journey.

Table 7.1. Assessing Perceived Trends Toward or Away from Ecosystem Health and Ecological Sustainability: Indicators of Damage

	Pirapora	*Bom Jesus da Lapa*	*Juazeiro*	*Petrolina*	*Penedo*	*Santana do São Francisco*	*Brejo Grande (Brejão dos Negros/ Cabeço)*	Holistic View
Change in Water Level/ Volume	"shallow river" "empty river"	"lower water" "shallow river"	"lower water " "shallow river" "dry river"	"shallow river"	"lower water" "shallow river"	"lower water"	"lower water"	"permanent river becoming temporary" "shallow river" "lack of water"
Change in Water Quality	"used to be cleaner"	-	"water is polluted"	"water pollution"	"water pollution by agro-toxins" more saline "sea entering more the river"	-	"more saline on the river's mouth" "water pollution" "parasites"	"water pollution by agro-toxins" "water polluted by sewage"
Change in Water Color	"in the past a more mud color"	-	"today it is green like an emerald" (less muddy)	-	"greener water"	-	-	-
Silting/ Erosion	"silting" "more sand banks" "growth of vegetation over rocks"	"silting" "broken river" "sand-banks (*c'roas*)"	"erosion" "more sandbanks (*c'roas*)"	"erosion" "silting"	"silting" "sand-banks (*c'roas*)"	"too much sand" "silting"	"sand-banks (c'roas)" "silting"	"silting"
Destruction of Riparian Zones/ Lagoons/ Habitat	"Destruction of riparian zones"	"Lack of lagoons"	-	-	"change in lagoons" "change in habitat"	-	-	-

Table 7.1. – *Continued*

	Pirapora	*Bom Jesus da Lapa*	*Juazeiro*	*Petrolina*	*Penedo*	*Santana do São Francisco*	*Brejo Grande (Brejão dos Negros/ Cabeço)*	Holistic View
Deforestation/ Change in Habitat	"deforestation" "destruction of *Cerrado*"	"destruction of riparian forests"	"deforestation"	"deforestation"	-	-	-	"loss in riparian forest"
Change in River's Regime	"end of annual flooding"	"lack of flood"	"lack of flood"	-	"lack of flood"	"lack of flood"	"lack of flood"	-
Fish Kill	fish kill (often)	-	fish kill (in 1984)	-	-	-	-	-
Decline of Fish Populations	"decline"	"fish disappeared"	"loss of fish species"	"decline"	"lack of fish"	"lack of fish"	"decline"	"lack of fish"
Presence of Exotic Species	"exotic species"	-	-	"exotic species: *Tucunaré*"	"exotic species: *Tucunaré, Macuri*" "*Rabo de Raposa*"	-	"exotic species: *Tucunaré, Macuri*" "*Rabo de Raposa*"	"exotic species: *Tucunaré*"
Air Pollution	-	-	Smoke from burning of sugar-cane plantations	-	-	-	-	-
Other	"streams and brooks drying out" "weaker river"	"disappearance of other species "	"River lost its speed" "loss of other species" "irrigation everywhere"	-	"loss of other species: shrimp, black worm, birds"	"lack of vegetation" "lack of junco" = *mato redondo*"	"crab disease destroyed crab's populations" "decline in shrimp population" "decline in junco"	"disappearance of other species"

Sources: Indicators from International Joint Commission (1989), Becker (1996), Nascimento (2003), interviewees and author.[3]

[3] Note: *Tucunaré* is *Cichla spp.* "Macuri" or *Maçunim* is a shellfish species, the *Anomalocardia brasiliana*. *Rabo-de-Raposa* is *Andropogon bicornis*. *Junco* is *Eleocharis elegans*. *Cebelo* is *Elodea sp. Piracema* is the reproductive season. *Defeso* is the protection of aquatic species' reproductive cycle.

Interviewees pointed out that the construction of dams is the major inducer of transformations (Figure 7.1 above). But, it is not the only one. I dug into the interviews to find people's explanations for the changes, namely causes and consequences of the effects upon the riverine environment. This section is an evaluation based upon the information provided by the participants in the interviews summarized in the table above. Existing studies and my own observations during fieldwork supported or refused the data local residents provided.

Dams. They have changed the river's regime affecting fish, fishing, and fishermen and imposing socio-economic impacts upon communities. Dams have produced a new, more uniform reality of the *São Francisco* River while creating a visually interrupted water body. From the perspective of the interviewees of all municipalities studied hydropower infrastructures have reshaped the *Velho Chico* into a "shallow" watercourse. In order to meet the regional clamor for electric power, and national and international demand for agricultural products, the changes have affected local people's support systems, the sources of environmental services. In the ways those alterations have taken place, they have impaired the possibilities of locals achieving their own needs. A religious figure described this effect in the statement below:

> People had the natural knowledge of the time... the fishing time, the harvest time... Today, with large dams... the river is officially controlled. Today the floods and discharges are totally controlled. Today people do not know anymore when the river's water level will be high and when it will be low. Then that totally controlled the popular riparian economy that is based upon family's agriculture. It also impacted fishing...
> (Religious figure, PC – phone interview, 13 Jan 2007, *Barra*)

A major concern arose from the present lack of annual natural flooding. Floods used to bring more than fish. Inundations also brought other aquatic species such as shrimp to the lower-SFR. The managed river altered the cycle of the water and of fish reproduction. In *Pirapora*, *Bom Jesus da Lapa*, and *Penedo* locals have noticed destruction of habitat. Few lagoons exist today and they are not flooded as they used to

be. In addition to the impacts of dams, in cities such as *Penedo*, sugar-cane and grass fields and landfill for urban purpose now occupy old lagoon areas. The water used to flood the lagoons and carry into them fish's eggs and youngsters from the river's channel, where mature fish used to spawn (Godinho *et al.* 2003, Gutberlet *et al.* 2007). Grown fish used the period of high water to go the opposite way. Fishermen and fisherwomen in the lower-SFR, in *Penedo* and *Brejo Grande*, observed that hydropower infrastructure is a physical obstacle to fish migration. Flooding events still occur, but less often than before the dams.

Dams hold back water and sediments. Sediment tends to deposit in reservoirs according to water permanence time and speed. An 83-year old, retired boat worker who also used to grow rice, beautifully described the changes in the river and how it now takes place in the lower-SFR,

> When there were floods, the entire region was full of fish, because fish and shrimp used to come. The water flooded lagoons with that yellow water, vitamin rich, which resulted from the mud [the water] removed from the river's banks... People grew rice...It produced important rice. Today the water seems to be filtered, isn't it? The water is kept by the dam. When the dam lets the waters go... the water comes clean, without the vitamin (Retired boat worker, PC, 04 Jun 2007, *Brejão-Brejo Grande*-SE)

In *Juazeiro*, a beautiful emerald-like (algae) color stays longer, replacing what used to be a long lasting earth and coffee-and-milk hue locals used to witness during floods and for lengthy periods afterwards. In *Penedo*, staffs of water treatment plants (WTP) have noticed changes too. Attempting to meet drinking water standards, WTPs used to fix turbidity problems. Now because a reduced level of suspended sediments comes with the water, they correct the color of the water by adding chemicals. It is greener now (Water treatment plant staffs, PC - group interview, 17 Jan 2007, *Penedo*-AL). In the lower-SFR, the existing characteristics of the waterway, shallow and transparent water, have favored the growth of algae species such as *Rabo-de-Raposa*

and *Cabelo*. The weaker current is unable to carry the plants away, and clearer waters favor their development (Holanda *et al.* 2005).

Change in salinity affects the growth and species composition in riparian zones. In the river's mouth region, salt water destroys junco and rice plantations. In the 1950s, Pierson observed that two species of a shellfish (*Maçunim*) existed: fresh and salt water ones – noticed by the difference in the color of their shell (Pierson 1972, vol. 2). The more saline river water of today allows the presence of salt water species in upstream areas where they were not common in the past. The indicator I employ for the increase in the salinity of the SFR is the presence of such species.

Fish and other aquatic species populations have declined in all municipalities studied. The transformations have affected both fish stocks and individual sizes. Large specimens are hard to find indicating the elimination of old growth specimens. In *Bom Jesus da Lapa* and in *Penedo*, fishermen need to stay more time fishing. But, they bring less fish, sometimes none, home. "A fisherman today spends five to six days fishing in the river and catches three kilos of fish... In the past the same fisherman supplied three, four districts of the city" (Group of fishermen and fisherwoman, PC - group interview, 22 Aug 2006, *Bom Jesus da Lapa*-BA). Fishermen do not catch enough fish anymore. In 2007, in *Petrolina*, catching a *pirá* became news. Local fishermen had not seen that fish species for many years. Environmental changes have introduced socio-economic and cultural adjustments. Formerly non-marketable species, such as *carí*, became a highly valued product in *Bom Jesus da Lapa*. The size of the catch used to make the process of cleaning the fish a social activity in *Bom Jesus da Lapa* and *Santana do São Francisco*. Since fishermen shared community and occupational identities, the destruction of fishing meant the passing-away of that traditional part of everyday life.

It is true that, other variables have acted upon aquatic resources. Overfishing has been mentioned, in *Bom Jesus da Lapa* and *Penedo*. "There are more fishermen than

fish." "Everybody is a fisherman today" (Group of fishermen and fisherwoman, PC-group interview, 22 Aug 2006, *Bom Jesus da Lapa*-BA). Other issues intensified the pressure. Fewer job opportunities exist in other sectors in the valley. Environmental change also disfavored traditional agriculture and strengthened the need for fishing as the direct and only means of survival. Water pollution and the destruction of habitat due to deforestation of riparian vegetation, including forests have also impacted fish, fishing and fishermen.

Agriculture. Historically, seasonal floods created the possibility for naturally fertilized riparian agriculture of multiple crops in the research sites of *Bom Jesus da Lapa* and *Juazeiro* and rice fields in *Penedo*, *Santana do São Francisco* and *Brejo Grande*. Agriculture has always been a source of sediment. But, it took place on a smaller-scale and intensity than it took place during the research period on the irrigated farms of the basin. Hydro-businesses have multiplied in the valley. Locals in all municipalities studied have noticed that silting is a problem. The fact is revealed by the presence of sandbanks, "c*'roas*". The weak river is not able to carry the sand away and dams interrupt its natural flow. In areas such as *Pirapora*, locals suffer with the excess of sediment; while in the river's mouth absence of sediment deposition causes problems. Silting upriver led to the growth of vegetation over *Pirapora*'s waterfalls impairing water withdrawal and tourism. This problem required dredging in 2007. Between *Santana do São Francisco* and *Penedo*, navigation has been very difficult during times of low water. The low water also has exposed the river's bed and "c'roas." Besides damming, the lower volume of water is also a consequence of irrigated agriculture as it demands and withdraws more water from the *São Francisco* and its tributaries.

Water pollution was both a consequence of land use and change, and a cause of other problems. The SFR carries the cumulative results of anthropogenic interferences. The interviewees identified agriculture as a major source of pollution, as seen in *Penedo*.

Mining activities in the upper-SFR's region have caused large scale incidents of fish mortality. In addition, heavy metals, when not causing immediate fish kill, enter the food chain, and bioaccumulate, passing through the food web (Oliveira and Horn 2006). Sewage, illegal garbage and refuse disposal into the river or along its banks and lack of management of waste contribute to the problem of a low quality of the water of the river.

Cross-cases Conclusions

The review of the literature, interviews and site observations helped me to conclude that some problems and consequences are site specific, but other impacts/trends are taking place throughout the river system:

Specific vs. Cumulative Effects. Upstream, people relate more to a specific dam as a cause of environmental problems when they are closer to it, such as in *Pirapora* and *Bom Jesus da Lapa* (*Três Marias*) and *Juazeiro-Petrolina* (*Sobradinho*). It is also true that in the first two cities, only one dam upstream exists, *Três Marias*. In the lower-SFR, besides *Xingó* Dam, local residents refer to the cumulative effects of the other dams upstream. In the lower reaches they seem to have a more holistic perspective of the dams' effects upon the *São Francisco* River.

Dams Impaired Flooding and Fishing. People at all locations seem to agree that dams impaired the natural cycle of flooding that used to bring fish. Local people believed that a better fishing season comes after flooding.

Reduced Contribution of SFR's Tributaries. The residents of the municipalities studied have noticed the reduced contribution of SFR's tributaries and the effects upon the *Velho Chico*. They saw water withdrawal for agriculture as one cause of the above-mentioned issue.

Modernization Detached People from the River. Constructions in riparian zones, such as docks, piers and bridges have interfered in people's perception of and use of the river. In the river's towns and cities such structures have been built to protect "us" from "it", the river, as illustrated by a clothes washer in *Juazeiro*, who said that she does not go to swim in the river since the construction of the pier. Urbanization moved people and attention away from the watercourse. The water treatment facilities provide water at home so most women no longer wash clothes in the river. Also in *Juazeiro*, several attempts have been made to remove a traditional community group from the riparian downtown area of *Angarí*. The transference of popular markets away from the river's front also created "distance" between the river and the inhabitants of the riparian cities. Commercial interactions based upon river navigation decreased.

Cultural Values have been lost. In the 1950s study published in 1972, Pierson (1972, vol. 3) wrote about the transference of knowledge from adults to kids. In their playing time, children used to copy the activities they observed taking place in their surroundings. For example, in the lower-SFR, they had fun using pieces of wood to float as boats in the river and creating gardens replicating rice fields. Older generations of grandparents, parents, uncles, and even neighbors influenced and taught new generations of fishermen, boat workers and small farmers. In that way, they used to keep the customs alive as example in *Juazeiro* and *Penedo*, fishermen taught their kids how to fish.

Today a lack of continuity exists. The traditional ecological knowledge has not been passed on, such as histories about the river and how to fish and farm. Folkloric and legendary information which formed the norm, the common laws, of human-environment relationship are being lost. For example, the belief in mystical creatures such as *Cavalo d'Água* and *Minhoção* used to impose "respect" regarding the way the river should be treated and used.

The Dying River. Interviewees have indicated a sense of hopelessness regarding the present and future of the river, and the future of the ecosystem services the waterway provides. Parents have educated their kids to do something else and to not follow in their footsteps. For example in the lower-SFR a boatman from *Santana do São Francisco* has advised his own kids to not seek their livelihood in the river as he and his father did because it cannot provide this anymore. In *Penedo*, riparian agriculture used to be a family activity. But the river has changed altering the lagoon's environment. In addition, the introduction of machinery and irrigation helped to change that social dynamic shifting the level of activity from family and community to business. Also in *Penedo*, a fisherman said that, fishermen in the past could count on the income from fishing. They "did not have to borrow from banks" (Fisherman and NGO member, PC, 19 Jan 2007, Penedo-AL). Professional fishermen cannot support their families anymore.[4]

Ecosystem Services Change per Timeframe

One of this research's focus is upon environmental justice. The river shall supply ecosystem services not only to out of basin residents, but also to those living in the basin. Past and present engineering practice should not prioritize serving those outside the watershed. This section lists the changes for those in the valley in ecosystem services for the period of time studied (Table 7.2 below). Given the current state of environmental degradation of the river, an interviewee questioned, "what *São Francisco* will be left for our kids?" (Crab collector's association head, PC, 06 Jun 2007, *Brejão-Brejo Grande*-SE). This research has focused upon provisioning and cultural services. Data from interviews, observations, and literature review showed that both categories of ecosystem services, as defined by the Millennium Assessment (2005), are affected in the case of the SFR.

[4] It is true that the standards of living have risen. For example, fishermen and fisherwomen recognized in *Bom Jesus da Lapa* that, differently from the past, they now have access to refrigerators, bed and mattress (Group of Fishermen and Fisherwomen, PC-group interview, 22 Aug 2006, Bom Jesus da Lapa-BA).

Table 7.2. Ecosystem Services

	Note
Supporting	
▪ Nutrient Cycling	Not assessed
▪ Soil Formation	Not assessed
▪ Primary Production	Not assessed
Provisioning	
▪ Food	Impaired supply of fish, shrimp, and other aquatic species, and rice from lagoon.
▪ Fresh Water	Impaired supply of clean fresh water due to point and non-point source of pollution, decline in supply during dry season.
▪ Wood and Fiber/Fuel	Impaired supply due to the deforestation of riparian zones and inland forests, impairments due to land use for impoundments and clean up of areas for agriculture and urban zone.
▪ Hydropower	Hydropower supply is impaired during droughts. The phenomenon is a 'natural' issue, but also might suffer from human influence (climate change).
▪ Navigation	Impaired by silting and low level of water.
Regulating	
▪ Climate Regulation	Not assessed
▪ Flood Regulation	Not assessed
▪ Disease Regulation	Not assessed
▪ Water Purification	Not assessed
Cultural	
▪ Aesthetic	Impaired by lower water, shallow river, silting and by the end of large boat navigation. Local people used to enjoy watching the big boats.
▪ Spiritual	Still used for religious purposes, but at a lower scale than before. Boat processions still take place in different regions of the watershed. A sculpture of the *Nego D'Água* stands in the *Juazeiro*'s side of the river. Older interviewees spoke about the river as a personified god.
▪ Educational	Parents and older generations do not share river histories as in the past, including the means of surviving from the river's resources as a member of a shared-identity group (e.g., fisherman and fisherwoman, boat worker, rice farmer, clothes washer). But, a sense of identity among the ones living on the river's edges still exists.
▪ Recreational	People still use the river to swim and for other water activities. New use forms have been developed. For example, they use the river for recreational fishing.

Trade-off: The Developed "Improved" River vs. Impaired Uses

This section focuses on the trade-offs regarding the current major uses of the river, hydropower and irrigated agriculture. The redefinition of the meaning of the *Velho Chico* for these two uses both impaired (Negative Effect-NE) and also improved (Positive Effect-PE) uses of the SFR's waters (Table 7.3 below). The human-environment relationship has

changed. The society also created new uses. *Paulo Afonso City* downstream of *Juazeiro* is a good example of that. Residents and tourists use *Paulo Afonso* hydropower complex's infrastructures for aquatic sports and sunbathing on a sand beach, *Prainha*. The city is known for ecotourism and new forms of sports. The bridge that links *Alagoas* and *Bahia* dates from 1959 (Pierson 1972, vol. 2). It is supposed to save the population in case of an eventual dam-related disaster. But, the bridge is used for bungee jumping and rappelling. The analysis of the cases presented other examples of "improved vs. impaired" uses.

Table 7.3. Trade-off: Improved vs. Impaired Uses

The effects upon these uses → / The effects of these uses ↓	Navigation	Fishing	Public Water supply	Electricity	Flood control	Recreation	Traditional Agriculture	Irrigated Agriculture
Electricity	PE1, NE1	NE2	NE3	PE2	PE3	PE4	NE4	PE5, NE8
Irrigated Agriculture	NE5	NE6	NE7	NE8	_	NE9	NE10	NE11

Note: Improved Uses-Positive Effect (PE) and Impaired uses-Negative Effect (NE).

NE1: In *Sobradinho* Reservoir, the new environment to provide electricity impaired navigation of older-type boats because the lake was too windy. The river was not regulated for navigation.

NE2: Electricity impaired fishing. Hydropower infrastructure transformed the flowing river into a sequence of managed lakes, from a *lotic* to a *lentic* environment. It spoiled fish migration and their reproductive cycle. Producing electricity caused a decrease in the populations of fish as in the lower-SFR, because populations cannot replace themselves in the altered habitat.

NE3, NE7: The management of electricity and irrigation created concerns for public water supply, such as in Penedo in the lower-SFR, when air entered the water treatment plant system because the river's level was too low (Water Treatment Plant staff-1, PC - group interview, 17 January 2007, *Penedo*-AL). In Petrolina, intensive agriculture is a source of contaminants in pre-treatment drinking water (Water Treatment Plant Staff-2, PC, 14 June 2007, *Petrolina*-PE).

NE4: Electricity impaired traditional agriculture. The level of the river is no longer based upon natural conditions, but upon human management. Locals cannot apply their traditional knowledge to assess when the river will be high or low and when is the right time to plant and harvest.

NE5, NE6, NE7: Water withdrawn for irrigated agriculture might restrict and/or impair other uses, such as the maintenance of water to allow ecosystem life and for hydropower generation. In the basin, this use already impacts navigation and water supply for domestic uses. The Rio *Salitre* used to be a permanent tributary, the Rio *Corrente* had more flow in the past, and *Minas Gerais*'s brooks and creeks are disappearing due to the intensive use of the water. Locals complained about the reduction of the tributaries' flow or contribution to the *São Francisco* River. As a fisherman said, "as we need our arms, we need our legs, we need our head to govern our body; in the same way the big river needed its arms, the rivers that formed it" (Fisherman, PC, 17 January 2007, *Penedo*-AL).

NE8: In the future, managers will need to choose between one or the other use, water for irrigated agriculture or for electricity generation. For example, if the inter-basin water transfer project (*Transposição*) of the National Integration Ministry will take place as proposed, the scheme will reduce CHESF's hydropower production by 2.4% (MIN 2004). This new large-scale infrastructure will traverse part of the basin and other regions of the Northeast involves North and East canals, in a total of 720 km aqueduct with

reservoirs, dams and pumping stations. It will increase hydro-businesses (e.g., the area of irrigated land). The project exemplifies what Richard Burton noted in the nineteenth century: Brazil has a bias toward monumental constructions since times past (Burton 1869, 1977).

Climate change is another consideration regarding water use and choices in the valley. Scientists agree that changing climatic conditions will affect hydrologic cycles (Baede *et al.* 2001). But the impacts and the ability to cope with the problems will not be distributed evenly around the world (Gleick and Kiparsky 2004) or the SF River Basin. It can trigger extreme events such as droughts and floods, increasing or decreasing river flows, evaporation, precipitation and infiltration. The valley already includes a water deficit zone.

NE9: Irrigated agriculture might in the future create opportunity for positive effects regarding recreation, such as aesthetic enjoyment. The visit to wineries is still an incipient activity in *Petrolina* and *Juazeiro* region. The negative effects are more visible as in the case of *Pirapora* with the impairment of tourist enjoyment of the waterfalls area – the beach of *Minas Gerais*.

NE10: Irrigated agricultural fields replaced areas of traditional crops and agriculture.

NE11: A limit exists regarding the extension of land and size of production the SFR will be able to irrigate.

PE1: The construction of electricity generating infrastructure namely dams and reservoirs, improved river navigation capabilities when navigation was one of the high priority uses, as for example, in *Pirapora*, during the non-rainy season soon after the construction of *Três Marias* Dam. Then, energy became the most important use of the river and the water body management focused on the achievement of that purpose.

PE2: A series of power stations and reservoirs along the river's course resulted in a better managed, fuller use of the river's flow for electricity generation.

PE3: Electricity improved flood control. Extreme floods used to submerge towns and cities more often. Now flooding only occurs if it does not impair hydropower management priorities, the generation of electricity.

PE4: Electricity has created new means of recreation in the valley. For example, residents and tourists use *Paulo Afonso* hydropower infrastructure for aquatic sports and sunbathing on a sand beach, *Prainha*. The city is the known place for tourism and new forms of sports.

PE5: Electricity improved irrigated agriculture. It is important for food production. The construction of water reservoirs assured a steady supply of water and electricity to power the pumps.

Unaccounted Costs and Benefits

Electricity has benefited locals, the Northeast, and other regions of Brazil. In the past, homes used kerosene and vegetable oil lamps, wood fires, and the moon to provide light. A few municipalities had energy systems, but they were precarious, employing wood or diesel engines. The demand far surpassed the supply of power. The service usually did not function twenty-four hours per day. The dams and reservoirs brought electric power, but led to the relocation of families, towns and cities. Some residents were never compensated for their loss (Araújo 1992, Horgan 1999).

On the negative side, in terms of ecosystems services we do not even know what was lost; for example, the real extent of the damage upon ecosystems in terms of species and ecological processes.

Conclusions on Assessing Sustainability

A former head of the Northeast Development Superintendence, SUDENE summarized some of the major issues that affect local people's current relationships with the river:

> ...the country chose, in practice, one option, that means, everything that has been done of importance in relation to the use of the water resources of the São Francisco River has been done to meet the insatiable hunger for hydropower from the region. Other important uses of the water have been left for later considerations. It seems that, the decision regarding the optimal use of the water of the São Francisco would be taken into the future... When the time arrives to plan the multiple uses of the waterway, that means, for irrigation, industrialization, navigation, leisure, there will not be much to decide upon. The economic destiny of the river will be hopelessly drawn... (Souza 1979, 221)

He was right in the sense that hydropower still dominates. But the infrastructure necessary to achieve that goal primarily has benefited irrigation in the valley. In addition, the economic destiny of the water body is not the only one at risk. Its health and integrity and capabilities to provide environmental services are also under threat.

The indicators of damage showed that the SFR system is far from being sustainable. In addition to the damage existing as a consequence of the long-term unsustainable use of the stream, namely silting, the system is still exposed to new threats. Part of the water removed for different supply such as domestic, commercial, and industrial returns to the river as sewage. Another problem is that not all pollutants come to the system as easy to identify point-sources. Water for agriculture leaves the river through pipes, but returns to the *Velho Chico* in a lower volume and as runoff and with agricultural pesticides, fertilizers, and biological contaminants. In addition, the system has not been able to provide the services it used to supply in the past, such as rice growing, fishing and navigation services.

Findings-and-Discussion: Assessing Public Participation – The New Role of the Public in the Management of the River's Water Resources

Participation and Conflict Resolution

The natural boundaries of the river basin delineate the new governance system of the water resources of the valley, employing a more holistic alternative. The Law#9,433 also mandated a decentralized and participatory approach of management. This section focuses on the work of the SFRB Committee. It is based upon the analysis of the interviews with CBHSF's members and with those who have participated in the group as consultant. This section also includes the analysis of data from my observations of the CBHSF's meetings and from the literature on water resources governance.

According to the interviewees, the CBHSF is the "parliament of water." The *Oxford Dictionary* (2003, 1084) uses the United Kingdom's meaning to describe the term "parliament" as the "highest legislature, consisting of the Sovereign." But, in the new Brazilian institutional framework, in the National System of Water Resources Management, the National Water Council and not the CBHSF occupies the position of a supreme decision maker in the matter of water resources management. Thus different assumptions exist about who is in charge.

In addition to the possibilities of participation as organized groups in the CBHSF, in that first instance of a "parliament of water," the national constitution and other legal instruments described in Chapter IV and Chapter V empower the members of the Brazilian society to fight in favor of a healthy, clean and safe environment, by using the judicial system, undertaking for example civil actions. Nonetheless, the outcome is not always favorable for the health of the ecosystem, including its people.

Research participants believe that, *de facto*, the committee is a state structure, with a democratic and participatory voice that discusses issues and seeks almost consensus in its decisions. The members make decisions based upon a two-thirds majority

[CBHSF Bylaw of 2007]. It is truly a legislative body. Its primary role is not of policy implementation but of policy making. With that interpretation, I agree: the evidence supports this claim.

The interviewees acknowledged that the management in place now with the CBHSF differs from the governance system which existed before it, regarding participation. Elected members and governmental appointees of various sectors of the society are involved in planning and decision-making processes. No doubt, it has changed the way participation in water resources management occurs in Brazil. The committee unites under one roof, various participants and perspectives on the SFR and on water resource management. The entity deals with questions regarding quality, quantity and multiple uses of the basin's water resources. The SFRB management plan bases itself upon those aspects, and guides the work of the CBHSF. In addition, outside views also have a chance to be considered. The committee or its regional consulting chambers hold public meeting to discuss the issues which the plenary considers relevant. The regional chambers have hosted several public meetings in different places of the watershed.

I initially imagined that the CBHSF would include a higher level of participation of average citizens. But I did not see many of them present at the meetings. This entity of the new system of governance represents an evolution to an approach to include more stakeholders. But the CBHSF was not for the general public. It did not inform the broader society and did not have tools to include their concerns besides the inputs provided during discussions in the meetings that the general public attends. Indeed, the inputs from the outside stakeholders were accounted for in a narrow sense. The committee held regional meetings and participants could discuss local issues. However, the watershed is 640,000 square kilometers in size and many residents had no real access to the meetings.

The CBHSF itself had not yet been able to undertake large steps towards projects for river restoration. But, the CBHSF has worked for the general good, the SFRB system. The conclusion results from the observation of the decisions which the committee had taken (e.g., management plan, taking a stand against *Transposição*, suggesting an ecological discharge, moving toward the creation of a delegator agency, and recommending water body classifications). Its work was based upon the strength of a selected number of people. This fact could be observed looking the list of its members: the same names were present in different management periods and sometimes for different positions. According to an interviewee and to the literature on water governance in France, mayors' participation made the model work (Leal 1998; Moraru-de Loë and Mitchell 1993; NGO-CBHSF, PC, May 24, 2007, *Belo Horizonte*-MG). But in the Brazilian case, the strengths came particularly from the more engaged members.

The CBHSF was based upon the idea of representativeness. It implied that its members expressed stakeholder group's views. But, it was not always possible; given the basin's size and variation. The CBHSF had attempted to solve that issue by including members from different states and groups.

In the CBHSF, equal possibility of participation exists in theory among its members elected by their own peers. In the public meetings I attended (e.g., plenary, regional meetings) after CBHSF's initial exposition, it opened the floor to all, including the visitors, to participate by asking questions or providing comments. Nonetheless, as in most meetings, some will end up participating more than others. People's backgrounds influence their public behavior. It is important to use a tool to get inputs from all, before and after these meetings, to allow a full participation, such as a questioner, comments sheet, and a message or voice recorder system allowing for anonymous submissions. This is important because the public will be more inclined to participate without worries of being punished after providing a contrary or controversial point of view.

In terms of content, people and the organizations or institutions they represented brought different perspectives to the debate. For example, during the XI and XII Plenary in *Belo Horizonte, Minas Gerais*, the representative of one federal ministry had a very different agenda than the other members of the committee. Conflicts of interest were also observed such as pushing towards a state river water agency and not a unified watershed agency.

All interviewees believed in the importance of the CBHSF in terms of outcomes. Multiple reasons existed. The committee was important for people and general environment because it impacted positively upon the river and the people who lived from it. The interviewees emphasized the significance of the committee in the governance sense. I grouped their answers into two major categories, the respondents provided from none to more than one answer (Table 7.4 below). The CBHSF is a positive influence while it also introduces a differentiated form of water resources governance. In reality it broke new ground in Brazil. In the answers one can observe, the importance the interviewees gave to the idea of a place for debate, discussion and for a decision-making setting and related issues. In the committee all votes have the same weight.

The research participants were more realistic. They acknowledged that despite the work already done, namely the implementation of the structure of the CBHSF, the approval of the management plan, and the first steps for the protection of the river demanding its restoration, many goals still lay in the future of the institution. The major targets mentioned have to do with the 1997 Water Policy's instruments: the creation of the SFR's Water Agency and implementation of the payment system for the allocated water of the *Velho Chico*. Nonetheless, CBHSF's possibilities of influencing change are impaired by the stone wall of the Water Council, the continuing strong power of executive entities of the federal government (e.g., Integration Ministry) and political forces.

Table 7.4. CBHSF: Potential Importance of the CBHSF Governance System

Positive Influence
- Influences water resources management in Brazil - Inspires other watershed-based committees - Motivates people from other rivers and watersheds to prevent damages such as the ones observed in the *São Francisco*
Model: Introduces a Different Form of Management
- With multiple actors - A consensus building entity - Provides an arena for conflict resolution - A place to equilibrate the forces of the various users - Legal place for discussion - Place for discussion - Different people able to discuss issues and decide upon - Place to deliberate - Place to make decisions - Proactive and not reactive model of participation - It will channelize resources for the watershed - An additional way of participation besides citizen initiated - Good technical body - Brings attention to issues

Source: Interviewees for the study.

Interviewees' views regarding what the CBHSF really should do or become were not different from what the CBHSF bylaws and the 1997 Water Policy specify. Under the research subjects' perspectives, the CBHSF should have discussed water related issues, restored the river and reduced existing threats, and implemented the water resources management tools. In addition the CBHSF bylaws mandated integration of policy at different levels [CBHSF bylaw of 2007]. Members saw the need for reaching a broad audience. The interviewees did mention the importance of the CBHSF as being an intermediary between society and government.

Outside of the CBHSF, but still in the water resources management system, the issue is different. CBHSF's position has been overruled, undervaluing the process of participation and conflict resolution the committee has been able to craft. It is important to keep in mind that, the federal government created the CBHSF to "allow" the

implementation of the inter-basin water transfer project (State Agency staff- CBHSF, PC, 09 Jul 2007, *Salvador*-BA). After the 1997 Water Policy, legally, water use and allocation in any water body needed to be discussed by its basin committee and be included in the management plan for the watershed, especially in the case of such a high impact project. The initial focus was not river protection, but justification for the inter-basin scheme. It was also true that the inter-basin project brought the river to the spotlight. The revitalization project has also been perceived as an exchange coin for the inter-basin scheme. Ex-president Fernando Henrique Cardoso, a firm believer in the priority of economic growth and Neoliberalism, created the committee and the restoration program on the same day.

Collaboration and Multi-stakeholders Engagement

The members have shared tasks as observed in chamber meetings. People seemed to be very comfortable and interested in making the CBHSF work. The National Water Agency – ANA has played an important role. Its staff has prepared studies for the CBHSF, and ANA has subcontracted the development of research and made accords with state agencies to undertake projects. For example, IGAM-MG, Minas Water Management Institute worked in the user registration process for the part of watershed in that state. The National Water agency and water related institutions of the states and Federal district created the plan that CBHSF approved. But, ANA's participation as noted by some interviewees, it is a threat to CBHSF's autonomy.

Some 63% of people interviewed linked to the new model of engagement (CBHSF's individuals) had previous involvement in actions of public participation. Nevertheless, the engagement in their personal or public life did not necessarily imply dealing with water related issues. Individuals had been connected with church movements, neighborhood associations, professional organizations and political parties.

The group also included ones linked to students' assembly, water user groups, agrarian reform issues and a wide-range of environmental reasons. Participation is also part of the job of professionals who represent user groups, civil society's associations and governmental entities. Interviewees have been involved for non-exclusive motives and they formed a diverse group of people, including fishermen, engineers, and municipal, state and federal agencies' staff.

The 1997 Water Policy mandated that members of water resources user's groups, governmental agencies, and civil society "shall" be involved in the river's committees. In an Ecosystem Approach to watershed management the ones who cause the problem shall be represented in the participatory process as well as those who must act to address it (Becker 1996). It is important to also include the groups that suffer its effects as well to find socially acceptable alternatives. Most of the CBHSF's interviewees acknowledged that all involved parties that should be represented, are present in the *Velho Chico*'s committee, the "big and small" (Civil Society Representative - CBHSF, PC, Aug 2, 2006, *Juazeiro*-Bahia). The research subjects recognized that the CBHSF has even done things to increase participation. In fact, in 2007 the committee decided upon changing its bylaws to alter the number of voting members from 60 to 62, adding two seats for indigenous people's representatives. Members of that group demanded more participation, despite representation that already took place throughout the federal agency in charge of protection of indigenous people's rights (FUNAI).

The CBHSF has also created the possibility of involvement of members of other traditional communities, the *Quilombolas*, whose heritage is directly linked to descendents of escaped-slaves. Members of this group demanded participation too. They now occupy the traditional community slot that indigenous groups' representative once used. During the interviews, few had mentioned that *Quilombolas* (maroons)

should have been represented, as well as larger irrigators and more municipalities' representatives. The third category had specific slots assured by law as government.

In the broader scheme, the only group I believe is still missing representation is of clothes washers. They do not form such a large population as before, but they are still present in municipalities along the river, as I saw in activity in *Pirapora*, *Bom Jesus da Lapa* and *Santana do São Francisco*.

The CBHSF created opportunities for the participation of non-voters too. It involved experts with proficiency in a needed subject or area, as in the case of NGOs that had represented indigenous people in the Traditional Community Working Group. Consultants are nominated and/or invited to be part of a working group [CBHSF bylaw of 2007, Art. 32]. But, the participation of average citizens in the CBHSF was more limited. Individuals could take part in open meetings such as the plenary sections that occurred twice a year, and at special plenary meetings. They could also join public meetings the committee and consulting regional chamber might hold.

The interviewees were very positive about their participation in the SFRB committee. Representatives of the various sectors of the society were engaged and had the opportunity to participate and express themselves in plenary and working groups. "Space exists for all [sectors] to participate," a consultant confirmed. As a governmental entity, participation occurs in the form of representativeness (CBHSF-consultant, PC, 07 Jul 2007, *Salvador*-BA).

The CBHSF had a paid administrative staff. Members of the committee are not paid for their participation. The CBHSF assured participation of the civil society groups' representatives paying for their trip and stay when meetings took place in a location different from a member's residence. Some complaints arose in relation to how the payment took place. It occasionally happened only just before the trip, impairing the

organization of the travel. It also took place post-event as a form of reimbursement. This fact made impossible the participation of those unable to find a temporary loan.

The plenary takes place in one municipality of the valley or in the capital of states which forms the watershed. It is up to the plenary to decide the locale of the next meeting. Regional gathering with similar topics occur in different places of the watershed. Working group meetings happen based upon a different scheme, for example, they take place in the executive secretariat's office.

In the valley, the number of forms of participation has increased during the historic period studied. Besides older citizen-initiated actions, that used to be a form of reaction, it now includes mandated participation, more as planning. New ways take place, such as in discussions and information sections, especially for its members. The size of the watershed makes participation difficult for the average citizen to follow the meetings. Traditional forms of engagement co-exist. Mandated participation did not replace citizen's initiatives. For instance, local residents have protested against the inter-basin water transfer project (Chapter V). In March 2010, the Movement of Dam Affected People - MAB occupied CHESF's building in *Sobradinho* to protest against the construction of two new dams in the lower-middle-SFR (*Riacho Seco* and *Pedra Branca*).

The level of mandated public participation in the CBHSF changes. In its initial phase, the ones in implementation groups visited municipalities of the valley to lead the formation of the new institutional arrangement. The mobilization went to the watershed and searched for the required participation. The candidates for the first election submitted their application and were chosen by their peers. According to an interviewee, in the first moment, it was important to include people with experience in representation, "collective practice" (CBHSF-consultant, *PC*, 07 Jul 2007, *Salvador*-BA). During periods outside of the electoral calendar, the institution is more isolated from the

municipalities. Fewer meetings took place in the valley in comparison with those for election.

The CBHSF was supposed to manage a river which drains an area three and a half times the size of New England. Any program to engage local population needs to bring serious logistic issues to the planning board, especially in the middle-SFR where the population density is very low. Cases existed of residents of municipalities visited that had not even identified themselves as part of the basin. "Some have no idea that they belonged to the watershed" (CBHSF-consultant, PC, 07 Jul 2007, *Salvador*-BA). The committee has still a long way to go in relation to the involvement of the residents of the basin in general.

Problems arise regarding the effectiveness of public participation. Successful contribution also depends on how the members organize themselves inside and outside of the committee's arena. Positive examples include collaboration such as inter and intra-group meetings. During such events, members share information and talk about and report on committees and sub-committees topics. At the other end of the spectrum, a member of a user's group from other state mentioned the difficulty of setting up meetings to discuss CBHSF's issues with peers. The first and second examples do represent groups more institutionalized than the third one. The committee needs to provide assistance to peer meetings taking place outside of the CBHSF's arena. Few occasions exist where a meeting is set up and the member and peers attend to exchange ideas on an issue. In addition to that problem, other forms of information and participation gaps exist. For example, a weak link exists among members and proxies. In general, they do not always exchange information, what can impair the continuity of the process. The member-proxy relationship is a bond that needs to be strengthened.

Based upon the idea of river-basin management, a fragile connection exists also between the SFRB Committee and the main river's tributaries committees. As reported by

an interviewee, "It is complicated. It is complex. It does not exist" (NGO-CBHSF, PC, 24 May 2007, *Belo Horizonte*-MG). Except the *Minas Gerais*'s committees that have been more active as, for example, providing comments to the review of the SFRB watershed plan (CBHSF 2004). The involvement of sub-basins is a vehicle to bring more local issues to the arena of the committee. The existing legal structure of both technical and consulting chambers already allowed participation of representatives of the sub-basin watershed committees [CBHSF bylaw of 2007, Art. 35].

Conclusions on Public Participation

The public's new role needs to surpass the long lasting lack of tradition in engagement in legally mandated forums of participation. As already mentioned in Chapter V, losing the fight against the inter-basin water transfer scheme projected a weak image of a committee which has striven to make the new model of management work for the *São Francisco* and the basin's inhabitants.

Findings-and-Discussion: Water Governance – Old vs. New

In the two previous sets of findings-and-discussion, this research addressed two general issues: assessed the impacts on the river, peoples' lives and on the system's capability as a provider of ecosystem services; and analyzed the new role of public participation in water resources governance focusing on the work of the CBHSF.

The first set (from p 319 to 335) showed how the system is far from achieving sustainability. The segment on public participation (from p 336 to 346) concluded that the actual form of management of the waters of the *Velho Chico* is very different from in the past. Now it is time to "tie up in knots," the multiple parts of this investigation that went from theory to practice. This section Water Governance – Old vs. New does two things: (1) it assesses policy's goals in relation to their consistency with ecosystem-based

management, appropriateness to address the problems, implementation and achievement of its goals; and (2) it pulls together what was learned from the other two findings-and-discussion sets and ends with the conclusions about the 1997 Water Policy and SFRB committee's effectiveness toward ecosystem-based management.

Ecosystem-based Governance: Effective Implementation

Organization's Compatibility with Ecosystem-based Management. The governance system of water resources in Brazil is a new model, and includes novel institutions such as the National Water Council and the SFR Watershed Committee employing a decentralized and participatory process. But governmental entities comprise a majority in the National Water Council.

The new governance system also includes older institutions that had to adapt to be able to undertake their new tasks. Up until the creation of the new model, federal agencies had implemented policy for the *São Francisco:* it was and still is a national resource. But the new system created and distributed new tasks among new and old institutions as described in Chapter IV. Water Resources Governance. For example, a large-scale complex project that will withdraw more than four liters of water per second from the SFR needs more than one permit from the National Water Agency: (1) one permit to select the resource for the project, and (2) one permit to start operations. In addition, licenses are required from the Environmental Institute. Federal, state/Federal District and even municipal agencies are the ones that monitor compliance with both water and environmental regulations.

Adaptable Management and Challenges. The 1997 Water Policy mandated the existence of the new institutional arrangements such the CBHSF, which has already adapted to meet the new demands. Its bylaws allowed a more inclusive participation of indigenous groups in the CBHSF. It also included a representative from maroon

communities. The instruments of the 1997 Water Policy were being implemented for the basin. The CBHSF approved the management plan. The National Water Agency maintained a user database. The CBHSF with the support of the National Water Agency decided upon the implementation of a delegator model for the *São Francisco*. This will implement the water use payment system.

States have adapted too. They have approved new laws regarding the governance of water bodies under their jurisdictions and those include SFR's tributaries. Some of them needed to alter their water resources management legislation to fit with the 1997 Water Policy (Table 7.5 below). State water resources management also follows the national general framework and structures such as: water council, state secretary, watershed committee, agency, and other state and municipal (e.g., concession) water management agencies. They contain similar instruments, such as permit system and charge for water use.

Table 7.5. SFRB Unit of Federation: Constitution/Organic Law and Water Policy

State	Constitution/ Organic Law	Law and Relevant Instruments of Water Policy
MG	-Surface and groundwater are of public domain -State water management system -Rational and multiple use of water resources -State in charge of creating programs of soil conservation to avoid erosion and silting, to restore water quality	Surface Water -Surface Water Law # 13,199 of 1999 -Water use access granted throughout *outorga*: concession (to governmental entity for public good for a maximum of 20 years) or authorization (private entity for private benefit for a maximum of 05 years) -Watershed management plan -State water information system -Water body classification according to its major use -Charge for water use -Gradual charge, insignificant uses free of charge -Penalties (e.g., fines, and temporary and permanent end of permit) -Compensation paid to municipality for the use of water resources in their land Groundwater -Groundwater Law# 13,771 of 2000 -Permit for use: concession (public good) or authorization -User database Other legal instruments: Water Conservation Program (Law# 12,503 of 30 May 2007)

Table 7.5. – *Continued*

State	Constitution/ Organic Law	Law and Relevant Instruments of Water Policy
BA	-Surface and groundwater are public resources -Water body in one municipality will belong to it -Hydro and mineral policy -The constitution mandated a state water resource management plan -Multiple use of resources Participatory, integrated and decentralized management -Charge for the use of water -Prohibits water pollution	-Surface and groundwater Law# 10,432 of 2006 replaced the Bahia Water Resources Policy Law # 6,855 of 1995 -Bahia Water Resources Management Plan approved in 2005 -State water information system -Water bodies classification according to its major uses -Permit system -Charge for the use of the water -Surface and groundwater use right allowed throughout concession (for public good) or authorization for other uses Concession: up to 30 years Authorization: up to 04 years -Water users database
GO	-Water and minerals treated as the same, as *common good* -State water and mineral resources plan -Protection of water resources	-Law # 13,123 of 1997 -Integrated and participatory management, multiple use of *water resources* -Charge for water use (concession, authorization, and permission for insignificant use): surface and groundwater charge for issuing *outorga* -Penalties: fines, temporary of definitive loss of permit -Database of water use: surface and groundwater -State Environmental and Water Resources Secretary can act as Water Agencies for watershed committee -It mandated a mineral and water resource management plan and system -Water use permit: concession (up to 12 years) or authorization (up to 06 years)
DF	-Surface and groundwater are common good -Water as an environmental issue	-Law # 2,725 of 2001 replaced Law# 51 of 1993 -Water resources in any part of the water cycle, surface and groundwater -Water as a common good -Decentralized, participatory, and science-based management -Water resources management plan -Water bodies classification -Water permits system. *Outorga* up to 25 years -Charge for water use -Water Information System -Penalties: fine, temporary or permanent suspension of water use permit Other legal instruments: -Law# 3,250 of 2003 created the Federal District water protection system -Law# 3,383 of 2004 provides incentive for large industrial water consumers

Table 7.5. – Continued

State	Constitution/ Organic Law	Law and Relevant Instruments of Water Policy
PE	-It contains a specific section (Section IV. Water Resources) on waters. All shall protect the waters -Surface and groundwater are public good -According to the constitution, it is prohibited to damage water	-Law# 12,984 of 2005 replaced the Law # 11,426 of 1997 -Water use granted via concession and authorization -Water uses right for groundwater provided by means of concession (public good), authorization (other purposes) -Timeframe depends on the use, up to 30 years -Charge for water use -Management plan -Water body classification according to its major uses (Law#12, 984 of 2005) -Information and Monitoring system
AL	-Surface and ground water are common goods -It contains a specific section (Section II. Water Resources) on waters. -All shall protect the waters	-Surface and groundwater policy. The Law # 5,965 of 1997 follows the federal model -Water as a public good -Integrated, decentralized and participatory management -Water a resource for multiple uses -Water bodies classification based upon major uses -State water use information system -Water resources state plan -Water right use granted through concession or authorization -Profit from the charge of water to be used in the execution of the state water
SE	-Surface and ground water are common good -It contains a specific section (Section III. Water Resources) on waters in the environment piece. -All shall protect the waters	-Law# 3,870 of 1997 -Water is a common good -Multiple uses -Decentralized and participatory management -*Outorga* for water use, including groundwater -Validity of *outorga* is up to thirty five years -It mandated a water resource management plan and system -Water body classification -Charge for the use of water -Penalties includes fees, temporary and permanent termination of water use

Source: legal instruments cited including states' constitutions and policies, ANA (2005), Pompeu (2006), Granziera (2007a), and IGAM (2008).

In the river basin, Minas leads other states as regards watershed-based management. It has the highest number of tributary watershed committees. Also a delegate entity that will act as the agency for the *São Francisco River* Basin committee will be from that state. *Bahia* has been environmentally in the forefront of other states in the basin. In 1973, it created the first state environmental entity in Brazil, a council, the

Conselho Estadual do Meio Ambiente. In 1995, the state approved a water resources policy and formed the first independent body to manage water resources, the *Superintendência de Recursos Hídricos* – SRH (Bahia SRH-BA 2005, State of *Bahia* Law#6,855 of 1995).

Municipalities. As already described, according to the 1988 Brazilian Constitution, water bodies are under the jurisdiction of the union, states or the Federal District. Nevertheless, municipalities are also a part of the new national system of water resources management. The CBHSF includes eight seats for representatives of municipalities (3 for MG, 2 for BA, 1 for PE, 1 for Al and 1 for SE). But, this is a very small number. The watershed has 503 municipalities. The management plan for the SFR included changes that had to happen at municipal level (e.g., sewage treatment, and garbage and refuse management). Watershed-based planning and water resources protection included land-based activities. Municipalities control land use based upon planning and zoning (Granziera 2006). Nonetheless, in the case of the SFR, the federal government had a lot to say regarding land use and change in the valley. Land appropriations for governmental projects involving hydropower and irrigation have occurred at the federal level.

At various levels of governance, including local, public participation in councils is also a way of influencing policy. Municipal councils might guarantee the participation of local entities in the decision-making process on river related uses and actions. Their perspective could then be included in the committee through the participation of municipalities' representatives in the CBHSF. A municipal council can be a tool to link the CBHSF and local entities. Local government members, agencies and municipal councils will have to be more involved to address existing issues and to prevent new threats. They would be also important because they would oversee implementation at the local level.

The situation differs among the municipalities studied in the valley in relation to environmental institutions. *Pirapora* does not have an independent environmental secretary. A municipal environmental council exists and meets every month. Half of its members represent civil society. It is a consulting body. In addition, the municipality participates in watershed-based committees. Pirapora has an environmental code (IBGE 2005b). Local government is in charge of overseeing both water and land uses in the municipality [Lei Orgânica de Pirapora 1990, altered in 1992]. The municipal constitution mandates that the local government should work to assure a safe environment for everyone [Lei Orgânica de Pirapora 1990, altered in 1992, VI].

The Agriculture Secretary deals with environmental issues in *Bom Jesus da Lapa*. The municipal environmental council meets monthly. Half of its members represent civil society, which included educational and research organizations, religious, and workers associations. Representatives of the city participate in watershed-based committee. Efforts were undertaken to create a local *Agenda 21*. Lapa also has environmental laws (IBGE 2005b).

In *Juazeiro*, the Environmental Municipal Secretary was linked to the Agriculture Secretary. The city's environmental council was active and held monthly meetings. Less than half of its members represented the civil society. Environmental, educational and research groups and workers associations were among its members (IBGE 2005b). Environmental concerns were present in municipal laws including articles that limits the use of agro-toxins in areas a thousand meters away from water bodies, and protects water resources against fertilizers and biocides (IBGE 2005b; Lei Orgânica de Juazeiro 1985, altered in 1990, Art. 142 and Art. 155; Vilas-Boas 2008). Juazeiro's Constitution established that the Municipal Environmental Council should oversee industrial discharge into water bodies [Lei Orgânica de Juazeiro 1985, altered in 1990, Art. 152].

Petrolina had a Planning and Environmental Secretary and a municipal environmental council (IBGE 2005b, Vilas-Boas 2008). The city was part of an inter-municipal and inter-basin water consortium. The local *Agenda 21* was under implementation (IBGE 2005b). The municipality also had environmental, workers and educational associations.

Petrolina's environmental legislation included land use zoning (IBGE 2005b, Vilas-Boas 2008). The Article 176 of the Municipal Constitution asserted the protection of the *São Francisco* and other water resources in the municipal territory, including ecosystems and their processes [Lei Orgânica de Petrolina1990, Art. 176].

In *Penedo*, the Environmental Secretary was linked to Planning (IBGE 2005b). An environmental council did not exist. The municipality participated in watershed-based committees. *Penedo* was in the initial phase of creation of its *Agenda 21*. The municipal law (Lei Orgânica) includes environmental issues (IBGE 2005b).

Santana do São Francisco had an Environmental Secretary (IBGE 2005b). But it did not have a municipal environmental council to collect public input regarding environmental issues. It participated in one watershed-based committee. It engaged in the development of the local *Agenda 21* (IBGE 2005b). The Municipal Law included environmental issues (IBGE 2005b).

Brejo Grande's Environmental Secretary was linked to Tourism Secretary. The municipality participated in the SFRB Committee (IBGE 2005b; Field observations, 08 Fev 2007, Aracaju-SE). The representative for this city, the mayor, also represented the *municipalities of the lower-SFR in a SFRB municipality association.*

Still Adapting. In Brazil, with few exceptions, a water bill refers to the payment not for use of the water, but for the treatment it received and for the cost and maintenance of infrastructure systems. The *Piracicaba-Capivari-Jundiaí* (*São Paulo* and *Minas Gerais*) was one of these exceptions. There the financial resources which resulted from user

charges for water have funded improvements in the quality of the water bodies through the construction of sewage treatment stations (Agência de Água PCJ 2006). The *Paraíba do Sul* basin located in *São Paulo, Minas Gerais* and *Rio de Janeiro* has also implemented this 1997 Water Policy's instrument and is charging for the use of water.

The SFRB Water Agency and the charging of water represented cases of institutional adaptability. In the case of SFR for example the choice of the design for the agency and the implementation of the system had stumbled into legal issues. According to Granziera (2007a) regarding the water payment system, the water agency needed to be a governmental body. The payment for water generated governmental resources that cannot be received by a private entity. An entity could administratively represent the water agency on a temporary basis. It would also be able to issue the water fees. But it would not be allowed to collect payments. Granziera (2007a) suggested that, in the case of the *São Francisco* River, a national resource, the National Water Agency – ANA should receive the public resource (Granziera 2007a). The Law# 10,881 of 1997 [Art. IV, Sec 1] mandates that ANA shall transfer the resources to a delegator entity (Granziera 2007a). In the case of the PCJ and *Paraíba do Sul*, ANA already transfers the resources generated by the water fee to their respective executive entities.

The water payment system in the SFR is being implemented. The National Water Resources Council has allowed the charge for the use of the waters of the SFR. The CBHSF had also already approved it. A delegator organization that works in *Minas Gerais* passed the selection process to become the CBHSF's water agency (*Associação Executiva de Apoio à Gestão de Bacias Hidrográficas Peixe Vivo*). The CBHSF approved it in plenary. Not all users will pay for the various uses of water. They form the group of

designated insignificant users if their withdrawal is less than four liters per second (ANA 2008).[5]

At the federal level, according to the Article 22 of the 1997 Water Policy, the priority in the use of the revenues generated in the watershed throughout water payment system should be in their application to the basin. The electric sector already pays municipalities, units of federation and the Union for the use of the water for hydropower purpose and for the employment of the land for hydropower infrastructure. Indeed the electric sector is the only group to-date which has paid for the water of the *São Francisco*. This new form of management faces several challenges and the spatial dimension of the basin is one of them. Few experiences existed to learn from and serve as a model in the beginning of the process for the SFR (e.g., *Piracicaba-Capivari-Jundiaí* and *Paraíba do Sul*).

Other forms of adjustment reside in the committee itself. The bylaws allow structural adjustments. According to its needs, the CBHSF has created five technical consulting chambers.

Various Challenges. The interviewee and I identified and, I described here major challenges of the CBHSF in addition to constraints imposed by federal agencies of the executive branch of the government and the National Water Council. Besides mandating public participation, the 1997 Water Policy required the use of river basin as spatial boundaries of governance. Nonetheless, the governmental system of Brazil has taken place at local, state/Federal District, and federal levels. Indeed, "[t]hese new deliberative forums are inevitably dependent on decisions made at other territorial levels" (Abers and Keck 2006, 602). The decisions take place within the context of political boundaries. The new policy mandated the introduction of novel entities into the

[5] The CBHSF has suggested the value of R$ 0.01 for m^3 of water withdrawal, R$ 0.02 for m^3 of water used and R$ 0.07 per m^3 of organic matter discharged into the river (ANA 2008, ATA CTOC of 06 Nov 2006). R$ 0.01 is equal to US$ 0.0058(13 May 2010).

older non integrated system; existing institutions and their values were incorporated as members of the new governance model.

Resources control was susceptible to political and economic interests and other influences. Corruption was present at various levels of Brazilian institutions and programs and the Northeast provided a long list of case studies. For example, governmental resources for drought alleviation projects, such as the work fronts (*Frentes de Trabalho*), have been used to build public infrastructures (e.g., wells, dams, reservoirs and roads) on private lands.

Lack of continuity of institutions and programs was also a problem with a long history in Brazil as Calegar (1988, 49) wrote,

> In the Northeast, over the years, while special new programs are created to support the regional development, others are shut-down, causing discontinuity in the governmental actions, creating people's mistrust, increasing the social cost, because, in general, an interrupted program means partially lost investments. (Calegar 1988:49)

The name of the institution was not the only change. Objectives and tasks changed too, such as in the case of the agencies in charge of water and hydropower management in Brazil: *Serviço de Águas*, *Divisão de Águas*, *Departmento Nacional de Águas e Energia*, and *Departamento Nacional de Águas e Energia Elétrica*, and *Agência Nacional de Energia Elétrica* and *Agência Nacional de Água*.

Regarding the management of the *São Francisco* River Basin in 1946, a deputy for *Bahia* suggested in his June 26, 1946's address to Brazilian congress, the introduction of an article to the 1946 Constitution, to protect the basin against the lack of continuity and to make sure that future governmental representatives would not interrupt or destroy any progress already made to the benefit of the valley. It was common to try solving issues without prior study of them and without present and future plans (Novaes 1989). Novaes (1989) also proposed that, the CVSF should be under the wing of the presidency in order to guarantee continuity even during ministry change, and also to be able to deal with

problems and solutions of multi-ministerial nature. But after twenty years, SUVALE replaced CVSF. Seven years later, CODEVASF replaced SUVALE. In the Northeast, SUDENE replaced ADENE which again replaced SUDENE. Sometimes the same institution stays, but with a new name.

Why does this happen? According to an interviewee, if "they cannot improve [the institution] they change its name" (Historian/Professor, interview, 17 May 2007, *Pirapora*-MG). But in the case of CVSF/SUVALE/CODEVASF a change in perspective and in focus areas did take place. It changed from focus on general infrastructure, to a lesser "paternalistic" support, and then to a large emphasis on irrigation projects managed by growers' associations (Historian/Professor, interview, 17 May 2007, *Pirapora*-MG). Lack of continuity is not the only problem. Some projects do not receive financial support even to start, as for example an irrigation program, PROINE in 1979 (Formiga 1999).

Accountability and Legitimacy. The SFRB committee did not have a legal or juridical personality. This fact affects accountability and legitimacy. For example, the National Water Agency needed to provide support, its presence in the committee, for the CBHSF to be able to function and to relate with other governmental and non governmental entity (CBHSF 2007). CBHSF would not be able to function without ANA or a state agency support.

The new management system had problems. The new model required the creation of independent institutions, but without initial independent source of support. The 1997 Water Policy did not assure any form of financial resource for the new committees before the implementation of its agency and water charge system. It is different from the regional federal institution, the CVSF that first used the watershed as boundaries for unified management. The 1946 Constitution assured 1% from the total national income revenue for that agency. The CVSF had an initial financial resource to support itself even before its implementation in 1948.

Governmental entities are involved and are the ones which assure legitimacy to the process. The CBHSF has direct ties with the executive federal government. As an example already mentioned in Chapter IV and V, the National Water Agency – ANA has played an important role in the implementation of this river committee. ANA has for instance undertaken and contracted studies, and provided support for the meetings to take place. The issue raises questions regarding the independence of the committee since ANA exerts such a strong presence.

State government agencies have also supplied technical skills and other forms of support for the committee (e.g., water bottles). For example, it assured the legality of elections, receiving the documentation of the applicants. Nevertheless, as CBHSF's interviewees recognized, it was difficult to keep the committee away from political influence and "thinking" as a unity, the watershed. Some states were helping more than others. It was difficult for the committee to act in favor of the common good of the basin and then not for the benefit of individual states.

CBHSF's interviewees recognized that state and federal agencies are more present in the *São Francisco* Committee than municipalities. But, a 2002 analysis of the environmental status of Brazilian municipalities reported that about 72% of the ones in the basin participate of the SFRB Committee or of sub-basins watersheds committees' activities (IBGE 2005). Nevertheless, the report did not reveal the form and degree of participation.

The participation of governmental and non-governmental members in the new form of water resources governance in the basin was per se progress for a nation whose many legal frameworks and instruments were never implemented and enforced, "*não pega*." The new form, in practice, was replacing the former model of centralized management (e.g., water use permit and environmental licenses issued by state and federal agencies; management plan includes public concerns). It was creating

possibilities for decentralization and participation, but implementation was still a task of governmental agencies. They were the agencies accountable for it.

Knowledge-based Approach and Capacity Building. The new form of management involved both scientific and traditional knowledge at the committee level. But, scientific knowledge prevails. One concern brought up by an interviewee was exactly about that: "the committee should not allow the dominance of intellectuals (Poder Público Federal-CBHSF, personal communication, 08 Mar 2007, Brasília-DF). Highly educated university professors and governmental employees were in the forefront of the committee. The CBHSF also included important holders of traditional knowledge, such as long-term basin residents and users representing, for example, fishermen and boat workers' associations. The CBHSF brought specialists and held workshops to increase the general understanding of the group, but based mostly on technical information.

Monitoring, Evaluation and Incorporation of Findings. The National Water Agency collected data and ran the National Information System of Water Resources (SNIRH). Other federal (e.g., INMET, ANEEL, INPE, MMA, and IBGE) and state institutions (e.g., IGAM) have collected information about water indicators. ANA and state agencies used such existing data for the creation of the management plan for the basin.

The system under implementation, together with data from state agencies (e.g., IGAM-MG) monitored for pollution, but some contaminants have not been traced back to their source, for example agro-toxins from agricultural runoff. The fact made it impossible to address the problem.

The plan for the SFR basin recommended the creation of the monitoring system to assess the use of water resources of the watershed (CBHSF 2004). In recent years, water quality data has been collected, which complements the long standing gathering of quantitative water data (e.g., IGAM 2008, ANA 2009). The results of monitoring will inform change in the existing and future plans and will inform management. In case of

droughts, the volume authorized to be used via *outorga* can be reduced or the outorga temporarily halted according to river uses' priority. Whereas a contingent plan is called for, I found no examples of such action taking effect in practice.

Institutional Capacity and Policy's Goals

Over the last century, management of the federal water resources had shifted from little or no control to governmental control (the 1934 Water Code) *de facto* exerted by the hydropower sector. The 1998 Constitution mandated and the 1997 Water Policy introduced a decentralized and participatory new phase.

Several attempts have been made to administratively manage the basin as a whole. During imperial time (from 1822 to1889), efforts existed to transform the SFR valley into an imperial province (Burton 1869, 1977). CVSF/SUVALE/CODEVASF used the watershed as administrative area for unified management. But, in terms of an ecological approach, only the 1997 Water Policy had mandated an ecosystem-based approach for the water resources of the valley, focusing on both quantitative and qualitative issues in the short and long-run, meaning for present and future generations [1997 Water Policy, Art. 2].

Nonetheless, not all the decisions regarding the use of the rivers' resources: have pushed the system towards sustainability, have followed the management plan guidelines, nor have been made by the rivers' committee. Even knowing that threats already existed for the SFRB system including lack of access to water in the basin, João Senra, representing the Secretary of Water Resources of the Environmental Ministry contested the management plan the CBHSF approved for the basin regarding the section on water use outside of the watershed. He based his opinion arguing that only the National Water Council could decide upon water use of the SFR outside of the

basin.[6] The National Water Resources Council approved the inter-basin project in 2005 [CNRH Resolution# 47 of 2005]. Another example of lack of concern about the environmental condition of the river was, the National Water Agency and the Environmental Institute had authorized river discharge of a volume lower than 1, 300 m^3, the ecological discharge, after *Sobradinho* Dam for the year of 2001, 2004 and 2008 even after the approval of the management plan which called for discharge equal or above that number [CBHSF Resolution# 39 of 2008, Santos 2009].[7] These measures reduced even further the water level in the lower-SFR where the low discharge into the Atlantic Ocean has already caused innumerable problems.

Prior to the implementation of the new management system, few examples existed of attempts to conserve and restore the ecological sustainability of the river environment, as documented here from the analysis of literature, interviews and field observations. Among these attempts are two that should be mentioned, such as the creation of the National Park in the area where the SFR rises and the reforestation of the area around *Três Marias* Reservoir. Unfortunately, the management goals which have received higher priority for the valley have nothing to do with river preservation. They are the development of hydropower generation capacity and irrigation projects.

Regarding people, sustainability goes beyond access to water treatment plants. No doubt that number has increased for the valley and for Brazil. But, not much has been said regarding the real access to water by locals, which also includes means to pay their water bill. Clothes washers also used the river due to those socio-economic reasons. "From a policy sciences perspective, the ongoing interaction of people in their efforts to achieve what they value is the foundation of all policy, including that of natural resources" (Clark *et al.* 2000). Additionally, the achievement of basic needs is the

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[6] This research did not weigh issues of concern. It focused upon the issues which most concerned the interviewees.

[7] Ecological discharge means the necessary volume to sustain aquatic life and ecosystem functions.

foundation to sustainable development. One of the problems in the case of the *São Francisco* River is exactly that. Before the new policy, local residents' views had not been taken into consideration when creating and implementing new policy for the management of the resources of the water body. Consequently, policy visions and goals have not represented and protected what they value. Legal instruments have not sought to meet local peoples' needs either. Ecosystem services such as hydropower are largely exported from the valley.

The *Velho Chico* is also a case of conflict among local people and those who wrote and implemented policy for the river away from the basin's reality. As mentioned by the research subjects in the interviews, the local residents see the major preferred uses as for: transportation albeit more in a nostalgic way; fishing; and water supply for domestic and small-scale riparian irrigation. The local residents want to be able to live and have a river environment providing for their existence as it did before governmental interventions. Governmental technocrats and users focused on pro-development schemes, which led to a reduction in the means to achieve people's basic needs based upon traditional ways (e.g., traditional riparian agriculture, fishing).

The SFRB Committee represented a new model of water resources governance as can be concluded by an analysis of the committee's legal instruments (e.g., by law, rules). The committee seeks environmental sustainability, the achievement of local residents' needs, and economic development. The committee has approved the management plan for the valley, and it has suggested an ecological discharge for the river's mouth. It also said "no" to the inter-basin water transfer project, which is perceived as a future threat to the water body and its environment and which has already increased water conflict among present and future users of the hydro resources of the basin.

Other institutions of the federal government have been implementing the restoration scheme, but it has taken place slowly. On the other hand, it is still pushing the river's environment towards a possible breaking point. The electric sector has suggested a further reduction in the river discharge, at *Sobradinho* Reservoir, from 1,300 m^3/s to the level of 700 m^3/s (Santos 2009).

Conclusions on Water Governance: Policy Effectiveness toward Ecosystem-Based Management

The Table 7.6 below provides a summary of the findings of the three sets of findings-and-discussion. In conclusion, thirteen years (2010) after the approval of the 1997 Water Policy, the various entities that structure the new integrated governance system of water resources management for the valley are still under implementation. Some instruments are not implemented yet, for example the charge for water uses, except the one for hydropower which existed before the new policy requirement.

The committee had no independent financial resources to implement its policy and projects through its agency. In fact, it still did not have a watershed agency. The CBHSF still depends on other governmental entities to move forward. It still sought autonomy and legitimacy. The system did not protect the *São Francisco* from either anthropogenic (e.g., new dams, management of the river's regime, climate change) or natural threats such as droughts. In addition, the new policy did not protect the river against political influences. It had been a model in-the-making of mandated participation at the committee level. But it needed to increase its visibility in the watershed. For example, some local residents interviewed had not even heard about the committee.

Table 7.6. Policy Effectiveness toward Ecosystem-Based Management.

Criteria to assess Policy Effectiveness toward Ecosystem-based Management	Yes	No
(1) Ecosystem Health and Integrity:		
Indicators: Indicators of unsustainability, change in the provision of ecosystem services, existence of impaired uses		
- Does the system exhibit signs of impairments?	x	
- Can the system continue providing goods and services for humans and other species?		x
(2) Ecosystem-based Governance:		
Effective Implementation		
Indicators: existence of natural over jurisdictional boundaries, presence of holistic management which takes natural systems and processes into consideration, examples of process and structural adaptation, illustrations of individuals and institutional leadership, examples of scientific-based decisions which takes traditional knowledge into consideration, existence of autonomous and accountable institutions, and example of adaptation due to information generated by the monitoring system		
- Are the organizations compatible with ecosystem-based governance?		x
Note: The committee yes, the national system no. It provides a wrong image of power-share		
- Is the management adaptable? **(yes, adding new laws)**	x	
Is the legal framework flexible?	x	
Is the organizational framework adjustable?	x	
- *Who is in charge and accountable for?*		
Note: In the end, the executive government is still in charge.		
- Is the new approach knowledge-based (scientific/indigenous)?	x	
- Does the new initiative create opportunity for capacity building (training/education)?	x	
Note: Yes, for the ones involved		
- Are there adequate monitoring and evaluation programs and means to incorporate the findings?		
Note: Yes. The management plan was based upon existing data. But, the system does not monitor for all causes of problems.	x	

Table 7.6. – *Continued*

Criteria to assess Policy Effectiveness toward Ecosystem-based Management	Yes	No
(2) Ecosystem-based Governance:		
Public Engagement and Participation		
Indicators: participation of a diverse group of stakeholders in the CBHSF; example of decisions which: creates opportunity for public engagement and includes the public, includes local knowledge and expertise; examples of: mobilizations initiated by the public, collaborative initiatives; presence of groups represented that should be involved, example of shared decisions, tasks and costs		
- Does the new approach foster collaboration?		
Note: Yes, the National Water Agency and state entities have provided support for the committee. CBHSF's members have shared tasks.	x	
- Are there alternatives for conflict resolution? Are they consensus based?		
Note: In the committee yes. In the broader structure, governmental entities decide. Several court cases have existed after the implementation of the CBHSF.	x	
- Is the public (multi-stakeholders) engaged?		
Note: Various sectors are engaged in the committee. The general society no.	x	
Does the initiative create opportunity for public participation in environmental issues?	x	
Does the initiative tap the technical and local expertise of the stakeholders?	x	
Does the initiative use the experience and expertise of the public to develop creative solutions to problems?	x	
Does the initiative create the opportunity for the public to be heard prior to a decision and thus enable the public to influence a decision?	x	
Does the initiative avoid or reduce later costs and time delays that often result from not having involved the public?		x
Note: The legal system is still the last resort.		
Does the initiative build public knowledge of the problem and the decision process?		
Note: Yes regarding the committee (e.g., discussions, expert presentations and workshop). But it fails regarding the society in general, including the ones who inhabit the watershed.		x
Does the initiative increase the credibility and legitimacy of the decision through a visible and accountable decision process which acknowledges the public's concerns?		x
Note: Yes at CBHSF's level. The broad system is a threat to the new participatory system		
Does the initiative enhance the prospects for successful implementation of the decision by developing some level of commitment by those with a stake in the decision?		
Note: Yes, it creates possibility because representative from different stakeholders groups are involved. But the system is not fully implemented yet and governmental agencies do not follow CBHSF's decisions. CBHSF has not power to enforce anything.		x

Table 7.6. – *Continued*

Criteria to assess Policy Effectiveness toward Ecosystem-based Management	Yes	No
- Is the public (multi-stakeholders) engaged? (*continued.*)		
Does the initiative avoid 'worst case' confrontation by serving as a direct means of conflict resolution through prevention or mitigation of undesirable impacts?		
Note: It tried in the case of the *Transposição*, but it did not succeed. It has tried in the case of reduced volume of river discharge.		x
Does the initiative use creative tools and means to attract public attention to environmental issues?		
Note: The *Transposição* brought the attention and not the CBHSF.		x
Does the initiative use approaches to maintain public engagement?		x
Is the initiative efficient addressing the issues of concern?		
Note: No. But, it is still in phase of implementation.		x
(3) Institutional Capacity and Policy's Goals:		
Indicators: use of watershed-based management; employment of long-term management respecting the timeframe of natural processes; examples of actions which have addressed existing problems and have prevented future threats		
- Are the policy's goals consistent with the aims of ecosystem-based management?	x	
- Are the policy goals appropriate to address the problems?		x
- Is the policy implementation achieving its proposed goals?		x

Source: Modified from Becker (1993, 1996), Nascimento (2003), and Pirot *et al.* (2000).

Local People' Recommendations on SFR's Governance

This research also sought to give voice to those historically less often heard in any decision-making process for the river. As suggested by Professor Conroy during an exam defense, "why not include their recommendations?" Despite the belief of some that only God or the government can do something to save the river, such as observed in the answers I obtained in the religious city of *Bom Jesus da Lapa*, local residents recognize that they are part of the problem and they too need to change their behavior (Table 7.7 below). They have identified positive actions a few individuals in their community are undertaking, such as working on environmental education programs and complaints when other people are not doing the right thing regarding the environment. Local residents interviewed observed that lack of public participation is part of the problem. But they have also noticed that, in the past, the public participated even less.

Local people also observed a change in the level of interaction with the river: from the subsistence to the large-scale; and in the level of economic activity impacts on the waterway from low to a broad range.

Table 7.7. Local People Assessment of their Own Behavior

	People doing Right	People doing Wrong
Environmental education	x	
Correct people when they are doing something environmentally wrong	x	
Not helping to protect the river		x
Do not know	x	x
People cannot do anything only government can	x	
Lack of engagement (public participation)		x
Lack of ecological consciousness		x
Displacing garbage and refuse into the river		x
Sewage discharge into the river		x
Fishing during the closure period (*defeso*), wrong size		x
Deforestation		x
Changed link with the river, not so close anymore		x

Many local users interviewed were uncomfortable with the questions regarding the government and assessing what it is doing right or wrong (questionnaire: Local Population, question VI.A and VI.B). Many rejected my hypothetical selection of them, the interviewees, to be the governor of the river (questionnaire: Local Population, question VI.F). I felt a strong sense of power delegation among them and it presents an important internal cultural barrier to effective public participation. Nevertheless, even rejecting the imaginary power position, many provided suggestions on what to do or needs to be done.

An extensive explanation regarding my lack of association with any Brazilian political party or governmental entity was necessary to overcome their worries about speaking about the government and its programs. I believe that their worries have three sources. One of them is the history of dictatorship in the nation and the consequence for the ones who reacted against that regime. The second is the strength that old and new colonels and/or political figures still have in the countryside region. In third, many people in the poor region are beneficiaries of federal support programs. They are not willing to lose such benefits in case I was in communication with a political figure or governmental agency. The answers were broad and not always directly related to environmental issues. They rarely specified the level of government they were speaking about.

According to them, governmental entities are undertaking positive actions regarding protecting fish (e.g., closure, restocking), but some clearly do not agree with enforcement measures (e.g., confiscation of product, fines). Fishermen receive a stipend during the closure months of a minimum salary.[8] Government has provided loans to small farms and fishermen (e.g., PRONAF). Government has also provided some degree of environmental education.

[8] In April 2008, it was about US$ 258.

The government is doing some things wrong. The *Transposição* project stands on the wrong side, together with dams. Local people affirmed that the government was a bad administrator, when it managed water resources and the environment of the valley. One interviewee even mentioned that, water use decision should be decentralized to municipalities, going against the model the new governance system proposes. The government also has built dams, did not take care of the environment and has not restored it, did not improve river transportation and undertook socially questionable large-scale resettlement policy (Collins and Krippner 1999, Gleick 1993, Cernea 1996).

The most fascinating aspect of the interviews with local people was that the recommendations they provided for the "government to do" are not necessarily identical to what "they would do" if they were the ones governing. For example, locals would include public mobilization, and restoration of traditional activities such as popular markets and navigation. They would let the river be in an almost natural stage. Regarding the government, the advices followed toward general recovery of the river (e.g., to restore the sites where river rises, to reduce use of water and diminish or cut pollution).

Not all local residents interviewed had participated in the new form of governance of the SFR. Some interviewees were not even aware of the existence of the committee. Most of the interviewees had heard about it from television or newspapers, but had never participated of its meetings. The committee was something far away. Some have also heard through peers and "the grape-vine". The form of engagement and level varied among those who have participated, ranging from attendance of meetings to helping to build the first committee.

Regarding the most conflicting issue under discussion, the inter-basin water transfer project, the local interviewees and the SFRB committee stood on the same side. They were against the scheme. Interviewees (local residents and CBHSF's members and

consultants) laid out various reasons for their rejection of the project. The Table 7.8 below illustrates the basis for the rejection. For example, the project can impair city's water supply, since the major use of the river will still be for electricity generation. Another reason was that they could not understand why to bring water so far away if others water sources exist there.

Table 7.8. Interviewees' Perception of the *Transposição* Project.

Deterioration of river condition
Degradation of fish populations
Fishermen's livelihood already impaired
Other available water resources in the Northeast and other alternatives for *Transposição*
High evaporation rate will reduce the water available in reservoirs and canals
High cost of water
The project will take longer to be built
Water from SFR has already been allocated to other uses
Project will bring dirty water to new areas
Future conflict among uses
Other projects within the basin exist without financial resources to be completed. Not sure if the project will be finished
Water will not be used for direct human and animal purposes
Lack of public participation on decision regarding *Transposição*
Revitalization should be the priority
People will die in the basin due to water inaccessibility if *Transposição* is completed

Note: Answers included none, one, more than one reasons.

This research uses multi-methods to include the perspective of different stakeholders. It included governmental reports, newspapers and articles expressing the views of those in favor and against the *Transposição* Project. For example, the section that describes the project in Chapter V is based upon the federal government report.

This research did not interview only citizens against the project. But, given the nature of this research which records the voices of the ones less heard or represented in official reports, the Table 7.8 above shows the reasons the interviewees provided as to why the inter-basin transfer was socially unacceptable.

The New Governance System: Summary and Update

The SFR system bears the consequences of past and present human interventions which treats its health and integrity. The system has changed and in doing so revealed improved and impaired uses. Besides the traditional model of citizen initiated engagement, new forms of participation in water resource management for the river have taken place. The new legal framework cannot fully protect the *Velho Chico*.

Changes have happened since the 2007-10 election. The administrative secretary moved from *Salvador* in *Bahia* to *Maceió* in *Alagoas*. On May 13-14, in a plenary, the CBHSF decided on the approval of a delegate entity (AGP *Peixe Vivo* with private juridical personality which is not profit-driven) that will act as its water agency, implementing CBHSF's programs. AGP *Peixe Vivo* is from *Minas Gerais* and the secretariat is moving from *Alagoas* to *Minas*. The payment system will only be able to be implemented after the approval of the delegate agency. The fourth election (2010-2013) is in process. It started on January first and will end on August 08 and 09, 2010 at a plenary.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Several final conclusions are drawn from the analysis of the *São Francisco* River case. **Locally, environmental and social costs have risen as development increased.** The system reveals various indicators of impairment, and sacrifices and benefits are unequally distributed among users groups. **The uses of the river have shifted from local in the pre-1950s to regional and international in the post-1950s era.** For example, the river does not supply as many fish for local fishermen but it provides hydropower to *Salvador da Bahia* and grapes for the Netherlands. **The new policy has not yet reversed the unsustainable (e.g., water pollution, silting and destruction of the fishery) ecological trend of the system.** The river faces present and imminent threats, such as raw sewage discharge; the *Transposição*, which is a work in progress; and new dams. Economic considerations occupy the highest rank in the priority list of decision-makers and **the intensive employment of the river for entrepreneurial purposes. Hydro-businesses are rising.**

Public engagement in the valley has changed in different ways. The basin and the broad Northeast have been the site for popular revolutions, but **water was one among many contested issues. Dams triggered a new form of participation of those affected by the perceived threat moving the attention closer to the river.** Despite the existence of older forms of citizen initiated engagement, the **new model of water resources governance now mandates the participation of stakeholders from multiple**

sectors, including civil society, in the decision-making process. Public participation has historically been politically and personally risky. Now, in theory it is participatory and decentralized. In practice, the **influence of the CBHSF in the final outcome of the management of the river is still very limited. The committee has attempted to push the SFR system towards a more environmentally protected pathway**, but the Brazilian model of doing things includes entities that can overrule committee decisions. For example, governmental institutions form the majority in the highest decision-making body of the new system, the National Water Resources Council. **One alternative for the CBHSF is to empower itself reaching for the support of the local residents (e.g., in municipal councils), that is the average citizens of the basin.**

Federal and regional governmental programs imposed upon local people threatened their way of life as riparian fishermen, boatmen and subsistence farmers. The changes altered and impacted their environment, which is their life support system. The new values did not correspond to the realities of their local societies. Many of them did not identify themselves with those imposed new identities. The development model and the new meanings of the river favored the production of hydropower to supply faraway Northeastern capital cities and the production of crops for export. Unfortunately, a clear **disconnect exists between the traditional local and national values, and the goals that had been imposed upon the basin residents**. Large-scale hydro-business does not address the problem of subsistence farmers and other local groups. The introduction of such form of production tends to accentuate the disparity between the lower and higher economic classes. Few small farmers, renters and sharecroppers have benefited from hydro-businesses. Environmentally, socially and economically speaking, the changes introduced for water management purposes seem to have involved more costs (e.g., degradation of river and fishing population) than benefits (e.g., jobs) for local people.

For me, this study brought three major enlightenments. The first is that, traditional knowledge is as important as the scientific (Berkes *et al.* 2000). The second is the understanding that sustainability and development should be about people and in the benefit of the common good. The third is that even knowing that we need to be ***multidisciplinary for Nature***, more does not mean better. I only was close to finishing when I learned to step back and realize that I was not able to describe all the details, processes and human-environment relationships which take place in the *Velho Chico* system. I also understood that, more research, conferences and publications do happen after graduate school. It was time to close a cycle. But, a policy scientist never stops with a conclusion.

A Policy Scientist's Evaluation: Successes and Failures of the 1997 Water Policy

The Table 7.6 in Chapter VII summarized the evaluation's results regarding the 1997 Water Policy's desired goals and how the management of the SFRB of Brazil fits with this research's understanding of an ecosystem-based management approach. The Water Policy has not yet achieved its proposed goals. It has not led the system toward sustainability. In relation to public participation, the CBHSF offers equal access to power in the participation of its members. But, in relation to the management of the SFR's resources, that means, who *de facto* controls the use of the river's resource, the higher body of the system, the National Water Resources Council and governmental entities of the executive branch hold that power. In addition, the legal system is still the last resort for conflict resolution.

According to the Policy Sciences Analytic Framework – PSAF, policy should meet certain criteria. This section evaluates the 1997 Water Policy against hard core principles (rational, politically practicable, justifiable, comprehensiveness and stability) of the framework developed by Harold Lasswell in the first half of the twentieth century. The

analysis shows how his contributions are still valid in the contemporary world in regards to environmental issues.

The Decision Process: The new form of management of the SFRB altered the structure of the decision process. "Structural changes may take the form of shifts in the degree of participation in power-shaping and power-sharing; or in the allocation of power among decision-making organizations" (Lasswell 1965, 289). In theory, in the case of the SFR one notices all those. In practice, the framework of governance shared the power of decision and management of the uses of the resources with new entities (e.g., National Water Agency) and with other institutions of the new National Water Management System. But, it is still under the control of the executive branch of government. Governmental entities of different levels form the majority in the National Water Resources Council, which is the highest source of conflict resolution.

The new policy mandated the existence of new institutional arrangements without providing any initial source of financial support. The lack of resources created a difficult situation in the case of the SFRB, because the support from the National Water Agency and from state entities can reduce committees' authority. It is a fuzzy line. Policy should have stability being lawful, enforceable and receive sustainable source of support for its implementation and enforcement. The 1997 Water Policy fails partially in those criteria.

The Social Process: The policy changed the decision process, as mentioned above. SFR people have participated of the new model implemented by the CBHSF and mandated by the 1997 Water Policy. Local residents' participation in the river resources management has shifted from a past characterized mostly by reactive alternatives to a present which focuses on preventative measures as well. In addition, citizen initiated participation occurs as shown in the Role of Public Participation, Chapter V.

The governance allows the inclusion and participation of members and values from different segments of the society. It shows that the form of governance is politically feasible. But regarding effective participation, in the sense of how much they can influence, it is another issue as described above.

Given the geographical limitations, such as the size of the watershed and its demographic density, and the lack of financial resources and time, the CBHSF has not been able to mobilize all communities of the valley, making the policy socially impracticable. A need exists for more local engagement. In addition, to the challenge list, one cause in policy failure is the use of imported solutions without understanding of the problem it has to address (Hirschman 1975, Clark 2002). As an interviewee said, the new model was created for places with water (State agency staff-CBHSF, PC, 09 Jul 2007, Salvador-BA). Time will tell how well it adjusts to a place without it.

On the other hand, the new water resources governance model offers a unique and important opportunity for public participation. Nonetheless, if the federal government is serious about it, the number of representative from each sector of the society, that is, from governmental and non-governmental ties, should be equal to allow a real opportunity to influence change.

The Policy's Goals and the Problem: Policy sciences seeks to identify trends and assess if they have tended toward the achievements of the goals (Eulau 1958). "Policy is democratic when it is consistent and compatible with human dignity" (Lasswell 1942, 25-26). The 1997 Water Policy seeks among other things the provision of water in quantity and quality for different generations. In the case of the SFR, inhabitants of the basin do not yet have access to a clean environment, water and other services which the river used to provide. The policy also has not met the criteria of common interest yet, since in the SFRB system, some uses and users are benefiting more than others from the use of the ecosystem services.

Policy problems are usually related to a lack of agreement about goals and/or about ends (Kecskemeti 1952). For example, the *Transposição* has not been accepted by the committee and many in the basin, but the federal government is building it anyways. The policy is not totally comprehensive fitting the nature of the changing situation. New policies have altered the 1997 law. For example, a law was approved to allow the use of the resources generated from water payment in the basin in the valley that generates it.

"Political behavior is oriented toward the future and anticipatory, as well as related to the past and retrospective" (Eulau 1958). In the Northeast of Brazil, regarding policy initiatives, drought was a "pressing" issue. But access to water in normal circumstances was not (Hirschman 1975, 391). The natural event was a "privileged" matter because it received a lot of attention especially when communication was improved and the environmental refugees were able to arrive in capital cities (Hirschman 1975, 391). This assessment recognizes that not everything attempted in the last sixty years in the basin has been a failure. For example, some of the works of the development commission for the valley – CVSF – spread the gains to the population. It built ports, health clinics and water treatment stations. It also supplied pump engines for small-scale irrigation. The new policy seeks to reduce present and future harms using an integrated approach.

According to Odum (1982, 728), "[m]uch of the current confusion and distress surrounding the environmental issue can be traced to decisions that were never consciously made." For example, government did not intend destroying the fishery in the SFR. But something was clear, economic growth will not always lead to social and political advancement (Hirschman 1975). Past policy for the valley brought direct, indirect, known and unanticipated effects on the environment and local residents. Local people should not be penalized again. One possible cause of problems will be the water

payment system. It will not guarantee public access to the resource; it can exclude more people from it.

The 1997 Water Policy has created institutions such as the committee, but it did not give the ability of fully maintaining and implementing its decisions in favor of the sustainability of the water resources of the basin and away from political influences. The policy allows decisions to be taken which are not ecologically-socially-morally justifiable since some inhabitants of the basin have no access to the resources. In addition, access to water in the watershed goes beyond the infrastructure to link houses to water treatment plants. Interviewees reported that even the ones having such infrastructural access in their residence still wash house wares and clothes in the river because they simply cannot pay the water bill.

Leverage Points: The Places to Intervene

This section revisits the SFR's system and sub-systems presented in Chapter II. It suggests areas where the new management body of the SFR, the committee, should intervene. In systems thinking theory, areas of intervention exist that will produce superior results. Such alterations will also depend on the system's resistance to change (Meadows 1999). The most successful leverage points are "the power to transcend paradigms" and to change "mindset or paradigm out of which the system – its goals, structure, rules, delays, parameters – arises" (Meadows 1999:3). In the case of the *São Francisco* River system, this would mean to manage the water resources of the basin beyond international and national ideologies of the traditional understanding of economic development using a more environmentally friendly and sustainable approach.

For the SFR to sustain or meet basic needs of those who live in the basin, some reconsideration of the new policy is required. In practice, the Water Policy has transcended the old paradigm. The policy includes a more environmentally friendly form

of management mandating practices that will lead toward sustainability of resources use. Brazil took an important step in that direction when congress passed the 1997 Water Policy and when the president approved the creation and implementation of an ecosystem-based committee to be in charge of overseeing the governance of the water resources of the SFR watershed. The country changed the rules of the system, at least in theory. It was an essential stride also because the river system is, as I have demonstrated, mostly driven by forces outside of its natural boundaries, the basin. Then the next large-scale modifications in the governance system will have to occur at the national level, incorporating those changes into practices of management.

Since two important steps towards change and holistic governance have been taken, let's look at other places to intervene in the system. They are listed below in decreasing order based upon Meadows (1999:3)'s scale of effectiveness. Lasswell (1965) suggested that one should think contextually. In the ecological, social and political contexts of the SFRB system this research identified the following leverage points.

- The goals of the system: one goal that should be strengthened is in relation to the rational and integrated use of water [1997 Water Policy, Art. 2, II]. The objective could be met employing water saving and recycling techniques. It is important to find alternatives to reduce the use of water and, in addition, it is essential to recycle. Reuse of water and stop using water in crops that result in intensive "virtual water export" are things not heard of in the valley.[1]

- The power to change the system's structure: also in theory, has changed. The power of the system has been reallocated among different entities. The policy and new governance system is design to and includes new players (e.g., users and new institutions), creating possibilities of power sharing. However in the end, their decisions and preferences on important issues (e.g., minimal discharge at river's mouth) have

[1] The Revitalization Program undertaken by CODEVASF has a component on water reuse (MIN 2010).

been ignored or overthrown. But, in practice, the older structures still exist as part of the new management model. It is important to assess the weight of the institutional memory of members in such framework as to assure change in practice to a new paradigm.

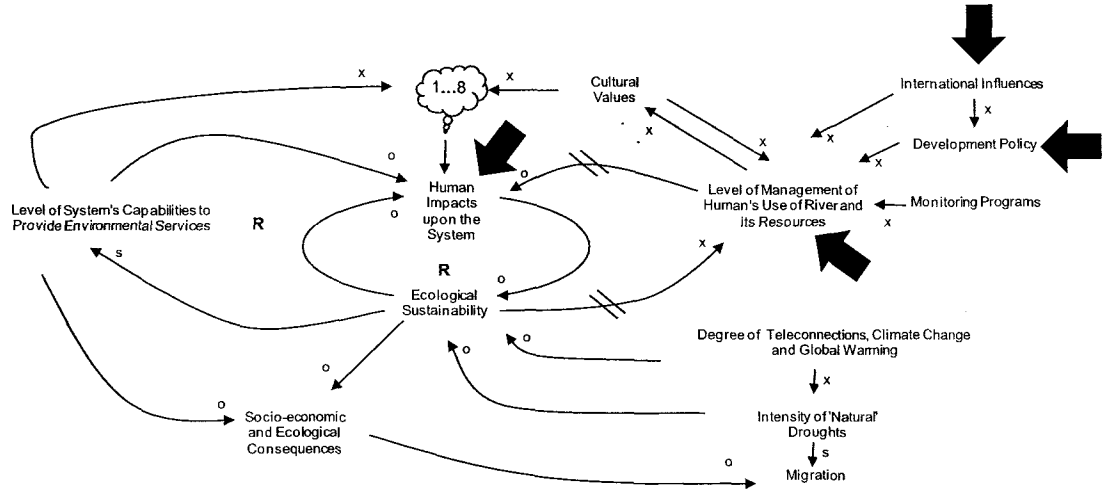
- The rules of the system: the system needs to start punishing polluters such as the large-scale ones which include municipalities, industries and farmers. It is also vital to offer incentives to help the users address the problems. For example, the Revitalization Program has helped municipalities to improve waste management systems. The reduction of the impacts with the implementation of sewage treatment plants and other forms of waste management in the SFRB's municipalities, will improve water quality and the general health of the water body. Policy will have to create ways to address agriculture related pollution, especially as large-scale soybean, coffee, and sugar-cane farming have increased.

- The structure of information flows: local residents need to be informed about the new system, the work of the CBHSF and how they can participate on the management of the river. Information will be necessary to strengthen the links among local residents-municipalities-councils-CBHSF, members-peers, and members-proxy, and CBHSF-sub-committees. Education of new generations on local's culture is also necessary to reestablish local peoples' links with the river environment. It is a key to change behavior and increase participation of the valley's residents in the CBHSF.

- The gain around driving positive feedback loops: Fish restocking is a must, and given the tremendous pressure on the SFR's fishery resources, long term fishery closure should be implemented in more areas. Short term closure is not enough. Such long-term closure has been proposed by some interviewees. In addition, hydropower stations should include implementation of controlled annual floods in their planning, since long term droughts do not occur every year.

- The structure of material stocks and flows: river restoration is necessary to stop the trend in bank erosion caused by deforestation. Reforestation programs in the basin could lead to an increase in river flow and aquifer recharge. It is also important to address the reduction of water loss, such as treated water that never arrives at final destination. The use of part of rain water is also an alternative, such as undertaken by the creative work of a forum of civic society organizations – *Articulação no Semi-Árido Brasileiro, Programa um Milhão de Cisternas* – P1MC. But, revitalization programs have only been slowly implemented.

The Figure 8.1 below shows the areas to intervene:



Legend (Anderson and Johnson 1997)

Same = s or Positive = +
Opposite = o or Negative = -
Reinforcing Loop = R (even number of o's or none)
Balancing Loop = B (odd number of o's)
Delay = //

Nascimento

1. Fishing Activity
2. Physical Changes resulting from Hydropower Generation
3. The Trend from Riparian and Dry-Land Towards Irrigated Agriculture - The Major Water Withdrawal/Use
4. Animal Herding - Cattle Ranching
5. Navigation
6. Deforestation
7. Riverbanks Erosion
8. Other Point and Non-point Sources of Pollution

x= unclear effect or effect in both directions: same and opposite

Figure 8.1. Most Important Leverage Points (large arrows)

General Recommendations

This section provides other general recommendations:

To Cover the Water Treatment Plants. The tanks of water treatment plants that I visited (e.g., *Bom Jesus da Lapa* and *Penedo*) are located outdoors. They inevitably receive input from rainfall and other sources, such as air pollution particles and sediments carried by wind. The addition might interfere with the quality of the water provided to the public (Donald *et al.* 2007).

To Monitor for Agro-toxins. It is necessary to implement a specific monitoring system for pollutants resulting from agriculture, which represent a major source of contamination. Only after identifying its sources, will solutions be able to be provided.

To Build Sewage Treatment Plants and Waste Management Plants. The basin fails in the area of sanitation. The valley lacks both sewage treatment stations and an adequate management of garbage and refuse.

To Distinguish between Fishermen - Those Who Fish for Option and those Who do so for Lack of other Survival Alternative. The *São Francisco* River has many meanings and uses for the local population. Some see the river as a large company because many lives depend on it (Fisherman, PC, 18 Jan 2007, Penedo). It is important to distinguish between those who fish because they want to and those who fish for lack of other means of survival. The creation of work alternatives for those who fish because they do not have another survival strategy can reduce the impact upon fish and other aquatic species for regeneration purpose. While some fishermen showed that this is the profession that they chose, others said that they had no other alternative (Fisherman, PC, 18 Jan 2007, Penedo). But in both cases the river is a source of livelihood.

Fishery Closures. The few fishermen who suggested a fishery closure considered it for a period longer than the four months that already takes place. They suggested at

least one and five years. This subject caused turmoil at the end of a group interview. This policy would probably not be generally socially acceptable.

General Public Engagement. As already mentioned, participation of local residents in the committee can empower it. But given the size of the watershed, public engagement is not an easy task. Alternatives include:

1. To create a community radio station within the basin, or a radio station program once a week on well known radio stations. The federal government uses the media to announce the alleged benefits of the *Transposição* Project. Newspaper articles and internet sites should be used. Nevertheless, fewer will have access to those media.
2. To make the general meetings on days and times when the general public can attend.
3. To advertise, that means, to reach a broad audience showing why local resident participation is important.
4. To pay stipends to allow them to participate. A day away from work is impossible for the ones who live such a subsistence life. An interviewee, a boatman, complained about his lack of opportunity to participate in the *São Francisco* River Basin Committee meeting. He said that, some people cannot be absent from their work to go to the meeting (Boat man, PC, 16 Jan 2007, Penedo-AL). The problem is that, possibly this would lead to an increase in the number of people who only would be there because of the stipend.

Lessons Learned

I am now more careful about what I propose to do. I now recognize that this project was very ambitious. When I thought that I was in the difficult part of the journey,

the worst part was still to come. I had a wonderful time in all the places I visited. I met very interesting people who shared their time and life experiences with me. I "survived" real and imaginary dangers. The roads were in terrible state. The probability of being robbed and assaulted was high. I almost was run over by a car. Two buses broke down. The drunken guys in the buses and the scene they put up annoyed me. I definitely enjoyed going home safe after each trip ready to start the real battle (data analysis and writing).

It was difficult to isolate environmental from other causes and consequences. For example, the construction of the bridge between *Sergipe* and *Alagoas*, in the lower-SFR, influenced negatively the amount of businesses for the ones working with boat transportation, as did the dams. But, it is difficult and almost impossible to separate these and other variables in the real world.

Environmental protection also might mean limiting individuals' access to resources. How to be fair? This personal journey at UNH has involved changing my own perspective. I arrived here with an idea of equity as meaning open and free access to natural resources. But my view shifted from "open access" to resources such as fish to close control, not necessarily by the government, such as during the *Piracema*, to avoid the "Tragedy of the Commons". But helping people finding ways to supply their needs is still necessary.

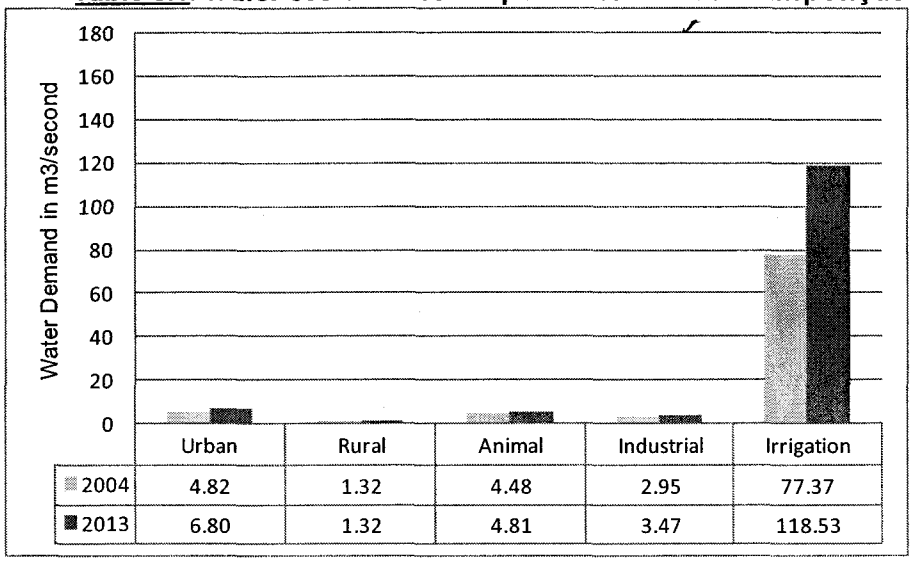
The interviewees have strong resistance to talk about government when I asked the question regarding "what is the government doing right and wrong". I needed to make my "no political association role" very explicit. But many forms of citizen initiated participation exist in the valley such as "*Pastoral da Terra*" "*Pastoral do Pescador*" though they are not often on the news.

Projection of Future Trends

According to Lasswell (1942, 30), "Policy thinking is "forward" thinking." The conflict of uses among the non-consumptive (e.g., hydropower) and consumptive ones (e.g., irrigation) is an existing problem that will worsen in the future given the growing projected demand for energy and food. In the past, it was thought that the construction of the first dams, such as *Três Marias*, would allow the removal of water for irrigation schemes without compromising other uses, for example, hydropower generation (Observador 1962). In the 1960s, no one would predict the massive rising demand for water use in the basin today.

The possible conflict did not take long to be noticed and discussed. In the late 1980s, an assessment for the valley showed that, it was possible to irrigate only a maximum of eight hundred thousand hectares without compromising electricity supply by the year 2000 (CODEVASF 2006c). A ten-year management plan has also projected scenarios for the increasing demand of water resources of the basin (Tables 8.1 and 8.2 below) (CBHSF 2004). The setting below, a "normative" scenario, takes into consideration the implementation of proposed programs and projects for 2004-2007, the achievement of goals regarding the expansion of irrigation until 2013, and the growth of other uses as well until 2010. The scenario applied an average annual growth rate of 5.18% for irrigation and 3.91% for urban consumption. The projection for other uses is less than the two above-mentioned. The water growth rate accounts for 0.02% for rural sector, 0.80% for animal uses, and 1.83% for the industrial segment (CBHSF 2004). The annual growth rate for the water use demand for the basin is of 6.5%. The total average use will grow from the 90.9 m^3/s in 2004 to 134.9 m^3/s in 2013 (CBHSF 2004). But, if the inter-basin water transfer project takes place as planned, the number will be 160.43 m^3/s (CBHSF 2004).

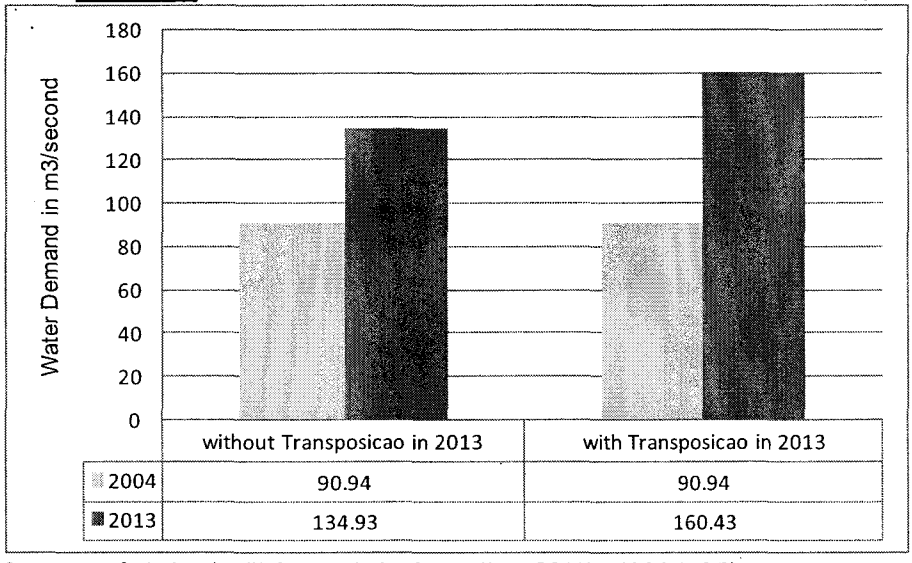
Table 8.1. Water Use and Growth per Sector without Transposição in m³/s



	Urban	Rural	Animal	Industrial	Irrigation
2004	4.82	1.32	4.48	2.95	77.37
2013	6.80	1.32	4.81	3.47	118.53

Source of data: built from data from the CBHSF (2004, 95).

Table 8.2. Total Water Use and Growth from 2004 to 2013 in m³/s



	without Transposicao in 2013	with Transposicao in 2013
2004	90.94	90.94
2013	134.93	160.43

Source of data: built from data from the CBHSF (2004, 95).

The projection into the future shows that the post-1950s economic or development rationality regarding the use of the river continues to dominate besides the use for hydropower, irrigation predominates. The *Transposição*'s plan will support both irrigated agriculture and aquaculture. It implies the use of the environmental services of the basin, on a large scale, by consumers outside of it. In addition, nobody can

guarantee that the project will assure social benefits for the ones living in the water receiving areas.

Another inter-basin water transfer project exists whose inspiration is as old as the *Transposição*. This one started with the idea of improving navigation. In 1870s, James Well traveled from *Rio de Janeiro* to *Maranhão* to investigate a water link between the *São Francisco* and *Tocantins* Rivers in the north and northern region of Brazil (Wells 1876, 1886, 1887; Keltie 1886). The idea did not become a reality, but neither did it dissipate. In 1959, engineer Coutinho suggested to use the *Tocantins'* waters in the entire semi-arid region of the Northeast. From 1975 to 1979 DNAEE, CHESF and ELETRONORTE investigated the possibility of such project for the purpose of hydropower generation (MME *et al.* 1983b). In 2000, a consulting company employed by the National Integration Ministry regarding the *Transposição*, asserted that the *Tocantins* project will link the *Sono* and *Sapão* Rivers, the first in *Tocantins* watershed sub-basin and the second in *Velho Chico* watershed (VBA 2000). A 2008 map for the *Tocantins-Araguaia* watershed published by *Tocantins* State Planning Secretary shows where the link will take place (Tocantins 2008a). The *Velho Chico* will be the receptor of water and aquatic species and no one knows the impact of them in the new river system and for the donor system as well.

As in any other part of the world, climate change will impact the future of water resources of the basin altering rainy and drought seasons. The *Transposição* of the *São Francisco* into northeasterners water bodies will reduce water availability and might increase local vulnerability to anthropogenic and 'naturally' occurring drought episodes.

Plans exist to build new nuclear energy facilities in Brazil and the basin has been considered a possible site.

Future and Further Studies

I will follow how the story develops. I would like to give back to communities the results of this study. But this time, my work will be based upon the questions they have. I also would like to disseminate their traditional knowledge throughout the valley creating little books for children with real life stories and people. I met amazing people and I heard great stories from them. I would like to share that form of knowledge with other people.

I will probably restart my long journey from where I stopped, that is at the river's mouth, *Brejo Grande* (Figure 8.2 below). I want to study the effects of the water resources management policy of lack of it on the land-river-sea-people interaction in the coast.

Figure 8.2. The Extreme Downstream
Source: Lucigleide Nascimento 2007

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III. Legal Texts

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APPENDIX A. INSTITUTIONAL REVIEW BOARD APPROVAL AND EXTENSIONS

UNIVERSITY of NEW HAMPSHIRE

April 3, 2006

Lucigleide Nascimento
Natural Resources, James Hall
125 Main Street, Unit 15
Newmarket, NH 03857

IRB #: 3686
Study: The Long Journey to become the "River of National Unity": The Sao Francisco River (Brazil) from 1940 to Today and the Interactions of Environment, Government, Law and Citizens
Approval Date: 04/03/2006

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved the protocol for your study as Expedited as described in Title 45, Code of Federal Regulations (CFR), Part 46, Subsection 110.

Approval is granted to conduct your study as described in your protocol for one year from the approval date above. At the end of the approval period, you will be asked to submit a report with regard to the involvement of human subjects in this study. If your study is still active, you may request an extension of IRB approval.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the attached document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* (This document is also available at http://www.unh.edu/osr/compliance/irb.html.) Please read this document carefully before commencing your work involving human subjects.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Manager

cc: File
Mimi Becker

Research Conduct and Compliance Services, Office of Sponsored Research, Service Building, 51 College Road, Durham, NH 03824-3585 * Fax: 603-862-3564

University *of* New Hampshire

Research Conduct and Compliance Services, Office of Sponsored Research
Service Building, 51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

24-Apr-2007

Nascimento, Lucigleide
Natural Resources, James Hall
282 Forest Park
Durham, NH 03824

IRB #: 3686
Study: The Long Journey to become the "River of National Unity": The Sao Francisco River (Brazil) from 1940 to Today and the Interactions of Environment, Government, Law and Citizens
Review Level: Expedited
Approval Expiration Date: 03-Apr-2008

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved your request for time extension for this study. Approval for this study expires on the date indicated above. At the end of the approval period you will be asked to submit a report with regard to the involvement of human subjects. If your study is still active, you may apply for extension of IRB approval through this office.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* This document is available at http://www.unh.edu/osr/compliance/irb.html or from me.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Manager

cc: File
Becker, Mimi

University *of* New Hampshire

Research Conduct and Compliance Services, Office of Sponsored Research
Service Building, 51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

09-Apr-2008

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Newmarket, NH 03857

IRB #: 3686
Study: The Long Journey to become the "River of National Unity": The Sao Francisco River (Brazil) from 1940 to Today and the Interactions of Environment, Government, Law and Citizens
Review Level: Expedited
Approval Expiration Date: 03-Apr-2009

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved your request for time extension for this study. Approval for this study expires on the date indicated above. At the end of the approval period you will be asked to submit a report with regard to the involvement of human subjects. If your study is still active, you may apply for extension of IRB approval through this office.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the document, *Responsibilities of Directors of Research Studies Involving Human Subjects.* This document is available at http://www.unh.edu/osr/compliance/irb.html or from me.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Manager

cc: File
Becker, Mimi

University *of* New Hampshire
Research Integrity Services, Office of Sponsored Research
Service Building, 51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

17-Mar-2009

Nascimento, Lucigleide
Natural Resources - James Hall
125 Main Street Unit 15
Newmarket, NH 03857

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University *of* New Hampshire

Research Integrity Services, Office of Sponsored Research
Service Building, 51 College Road, Durham, NH 03824-3585
Fax: 603-862-3564

25-Mar-2010

Nascimento, Lucigleide
Natural Resources - James Hall
125 Main Street Unit 15
Newmarket, NH 03857

IRB #: 3686
Study: The Long Journey to become the "River of National Unity": The Sao Francisco River (Brazil) from 1940 to Today and the Interactions of Environment, Government, Law and Citizens
Review Level: Expedited
Approval Expiration Date: 03-Apr-2011

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For the IRB,

Julie F. Simpson
Manager

cc: File
Becker, Mimi

APPENDIX B1. VERBAL CONSENT FORM

The Long Journey to Become the 'River of National Unity'

The São Francisco River Basin from 1940 to Today: the Interactions of Environment, Government, Law, and Citizens.

To participants in this study:

I am Luci Nascimento, a Brazilian citizen, and a Ph.D. Candidate in the program of Natural Resources & Environmental Studies at the University of New Hampshire in Durham, United States. My doctoral research is about the interactions among government, laws and citizens and the impacts on the environment and therefore on the life of those inhabiting the São Francisco River (SFR) Basin, Brazil, from 1940 to the present day. The purposes of this research are:

- To assess the new policy capabilities to meet stated purposes, such as to implement an integrated approach of management to the human uses of the SFR and its resources.
- To evaluate how the new policy differs from the policies of the past and to what extent it is more likely to lead to the sustainable use of the river/watershed and its resources.
- To uncover the role that citizens and citizen's groups have been playing in the management of the human use of the São Francisco and its resources.
- To assess the past vs. present regarding the ecological condition of the SFR and basin, and its capabilities as a provider of goods and services for humans and other species.

I seek to hear from you as one who has been involved in the case of the São Francisco River as a staff of a governmental organization, a member of a non-governmental organization, an environmentalist, and/or as a local resident of the basin. I would like to know your insights and perspectives about your experience. You are being asked to participate in a one to one and a half hour focused interview, preferably in person. Further contact (in person, by e-mail, by letter, by phone) might be needed to ensure that I have accurately interpreted your answers. I will take notes, but I will also request your permission to record the data in an audiotape. You will be able to cease the interview at any time. The tapes will be maintained securely for future research. They will be stored in my personal files at home, where only I have access.

There are no risks for you as a participant in this study. In any form of publication of the results of this study, I will quote you by name only with your written permission. "You should understand, however, there are rare instances when the researcher is required to share personally-identifiable information (e.g., according to policy, contract, regulation). For example, in response to a complaint about the research, officials at the University of New Hampshire, designees of the sponsor(s), and/or regulatory and oversight government agencies may access research data." There won't be any kind of compensation for the subjects of this research. The primary benefit will be your access to the final results of this research, but it will happen even if you do not accept to

participate in this study. Your participation in this study is voluntary and that your refusal to play a role will involve no penalty, if you decide at any time not participate in this research.

My advisor (Dr. Mimi Becker) and I can be reached, for future questions and/or clarifications, at the University of New Hampshire, Department of Natural Resources, 215 James Hall, Durham, New Hampshire, 03824. We can also be contacted by phone [(603) 862-3950], fax [(603) 862-4976], or e-mail [(Dr. Mimi Becker: mlbecker@cisunix.unh.edu) and/or (Luci Nascimento: lnn_unh@hotmail.com or lnn@cisunix.unh.edu)]. If you have any questions about your rights as a research subject, you may contact Julie Simpson in the UNH Office of Sponsored Research at (603) 862-2003 or Julie.simpson@unh.edu to discuss them.

I have read the above statement, or was informed on the matter of its contents by the interviewer, and agree to participate as an interviewee under the conditions stated above. I am aware I can discontinue participation at any time without penalty. My consent was given verbally.

Luci Nascimento requests my permission to record the interview. I verbally don't agree/ I verbally agree with the use of audiotape recorder under the condition that I may request that it be turned off at any time during the interview.

APPENDIX B2. TERMO DE CONSENTIMENTO VERBAL LIVRE E ESCLARECIDO

A longa jornada até ser transformado no "Rio da Unidade Nacional"

A Bacia Hidrográfica do Rio São Francisco desde 1940 até o presente (2007):

A interação entre o meio ambiente, governo, leis, e cidadãos.

Aos participantes desse estudo:

Eu, Luci Nascimento, brasileira, sou candidata ao doutorado em Recursos Naturais & Estudos Ambientais da Universidade de New Hampshire, localizada em Durham, Estados Unidos. A minha pesquisa é sobre a interação entre governo, leis, e cidadãos , e os impactos dessa relação no meio ambiente, e consequentemente, na vida dos que residem na Bacia Hidrográfica do Rio São Francisco (RSF), desde 1940 até a atualidade. Os objetivos dessa pesquisa são:

- Avaliar se a Política Nacional de Recursos Hídricos e a lei que criou o Comitê da Bacia Hidrográfica do Rio São Francisco têm capacidade de atingir os objetivos propostos, como por exemplo, implementar uma administração integrada do uso do RSF e dos seus recursos.
- Avaliar como essas duas novas políticas públicas diferem das alternativas anteriores, e em que extensão elas podem ocasionar o uso sustentável da Bacia Hidrográfica do RSF.
- Entender a participação da sociedade civil na administração do uso do RSF e dos seus recursos.
- Examinar as condições ecológicas do RSF e da sua bacia hidrográfica, no passado e no presente, e a capacidade desses ecossistemas de continuar fornecendo bens e serviços para os seres humanos e outras espécies.

Eu gostaria de ouvir de você, funcionário do governo/membro de organização não-governamental/ambientalista e/ou morador da Bacia Hidrográfica do São Francisco, quais são suas idéias e perspectivas em relação ao RSF. Solicito sua participação voluntária em uma entrevista individual, preferencialmente pessoalmente, de aproximadamente uma hora/uma hora e meia. Contatos futuros podem ocorrer (pessoalmente, por e-mail, carta, e/ou telefone) para confirmar que registrei corretamente sua resposta. Farei anotações, mas pedirei sua autorização para gravar as entrevistas. Se desejar, você poderá parar a entrevista a qualquer momento. As fitas serão guardadas em local seguro para estudos futuros. Elas serão mantidas nos meus arquivos pessoais, em casa, onde apenas eu tenho acesso.

A sua participação nesse estudo não envolve riscos. Em qualquer forma de publicação desse estudo, eu só citarei o seu nome com a sua permissão escrita. "Mas você deve entender que em alguns casos, o pesquisador precisa dividir algumas informações de acordo com certas políticas, contratos e regulamentos. Como por exemplo, em resposta a uma crítica sobre a minha pesquisa, funcionários da minha universidade, patrocinadores da minha pesquisa, ou órgãos do governo americano podem pedir acesso aos meus dados." Você não vai receber nada em troca da sua participação nessa pesquisa. O único benefício será o acesso ao resultado final dessa pesquisa, que poderá acontecer mesmo se você não quiser participar desse estudo.

Sua participação é voluntária, você não vai ser punido, não sofrerá nenhum dano por se recusar a participar, ou, se resolver a qualquer momento, desistir da pesquisa.

A minha orientadora, Drª Mimi Becker, e eu poderemos ser encontradas na Universidade de New Hampshire, Department of Natural Resources, 215 James Hall, Durham, New Hampshire, 03824, para responder qualquer dúvida e para prestar qualquer esclarecimento sobre essa pesquisa. Nós também poderemos ser contactados por telefone [00xx-1-(603) 862-3950], fax [00xx-1-(603) 862-4976], ou e-mail [(Dr. Mimi Becker: mlbecker@cisunix.unh.edu) e/ou (Luci Nascimento: lnn_unh@hotmail.com ou lnn@cisunix.unh.edu)]. Se você tem qualquer dúvida em relação aos seus direitos como participante nessa pesquisa, você pode contactar Julie Simpson na mesma universidade, no Office of Sponsored Research at 00xx-1-(603) 862-2003 or Julie.simpson@unh.edu.

Eu, participante desse estudo, li ou fui informado sobre o conteúdo desse termo de consentimento pela entrevistadora, e concordo em participar desse estudo como entrevistado sob as condições descritas acima. Eu estou ciente que poderei interromper a minha participação a qualquer instante, sem penalidades. Meu consentimento foi dado verbalmente.

Luci Nascimento solicita a minha permissão para gravar a entrevista. Eu, participante desse estudo, verbalmente não concordo/eu concordo verbalmente com o uso de gravadores na condição de que eu possa solicitar que o equipamento seja desligado em qualquer segmento da entrevista.

APPENDIX C1. FOCUSED INTERVIEW FORM: SFRB COMMITTEE MEMBERS

The Long Journey to Become the 'River of National Unity'

The São Francisco River Basin from 1940 to Today: the Interactions of Environment, Government, Law, and Citizens.

I. INTERVIEW INFORMATION

A. Time:_____ B. Date:_____
C. Place:_____
D. Interviewer:_____

II. PARTICIPANT INFORMATION

A. Name:_____
B. Title and/or Professional Position:_____
C. Address:_____
D. Phone:_____
E. E-mail:_____

III. ROLE OF INTERVIEWEE AND HISTORY OF INVOLVEMENT WITH RIVER/FRESHWATER ISSUES

A. Before your participation in the São Francisco River case, what roles have you played in relation to the use and management of river/freshwater resources?

B. How did you get involved?

C. What roles have you played in relation to the use and management of the human uses of the São Francisco River and its resources?

D. How did that start?

E. What roles do you currently play, if any, in relation to the actual management of the human use of the São Francisco River's resources?

F. How did you get involved?

G. In the present day, do you play any other role besides of the management of the São Francisco River (e.g., other committee/waterbody)? What one(s)?

H. If Yes for question G, How did that start?

I. What does the São Francisco River mean to you?

J. How should the São Francisco River be used?

IV. INTERVIEWEE PERSPECTIVES ON THE FACTS

A. To what extent are you aware of the role and actions of the São Francisco River Committee? What is its role?

B. Is the new committee important?
   a. Yes ( ). How?
   b. No ( ). Why not?

C. What types of actions has it taken?

D. How does the management of the São Francisco River and its resources today by the committee differ from before the existence of the committee?

E. What has been done differently?

F. Is the new committee important in relation to the São Francisco River and its environment?
   a. Yes ( ). How? Can you give me an example?
   b. No ( ). Why not?

G. Is the new committee important to people who live in the São Francisco River Basin?
   a. Yes ( ). If so, Why? In what ways?
   b. No ( ). Why not?

H. Does the committee impact the way people use the resources of the São Francisco River? Whose people (local, regional, national)?
   a. Yes ( ). How?
   b. No ( ). Why not?

I. What are some of the committee's goals?

J. In your opinion, what are the challenges?

K. If you could, would you change anything in the committee?
   a. Yes ( ). What?
   b. No ( ).

L. Will the committee have the authority and/or ability and/or resources to change the current situation of the river?
   a. Yes ( ). If so, How?
   b. No ( ). Why not?

M. Do you think that the results of the committee's work will be able to change the environmental condition of the São Francisco River Basin?
   a. Yes ( ). If so, How?
   b. No ( ). Why not?

N. Who are the committee's key players or involved groups?

O. Can you tell me about some of their actions?

P. In your opinion, does the committee make an effort to include all the groups or the concerns of all the groups that should be involved?
   a. Yes ( ).
   b. No ( ). If no:
      Who is missing?
      How could it/they be represented?
      Why is the participation of the absent player/group important?

Q. To your knowledge, what roles do federal and state policies and governments currently play in relation to the management of the São Francisco River and basin?
   a. Are you aware of specific examples?

R. Are federal and state governments coordinating efforts to carry out these roles/activities? How? Are they sharing costs?

S. Do federal and state policies and governments currently relate to the management of the watershed resources outside of the committee? How?

T. How have concerned citizens been involved in the decisions about the management of the São Francisco River and resources?

U. In your opinion, did citizen participation in river resources issues change after the creation of the committee?
   a. Yes ( ). If so, in what ways?
   b. No ( ).

V. In your opinion, is citizen participation in the committee effective?
   a. Yes ( ). How happens?
   b. No ( ). If no:
      What is missing?
      What could be done? How?
      By whom?

W. Would you like to add any other comment?

APPENDIX C2. FORMULÁRIO PARA ENTREVISTA INDIVIDUAL: MEMBROS DO COMITÊ DA BACIA HIDROGRÁFICA DO RIO SÃO FRANCISCO

A Longa Jornada até transfomar-se no "Rio da Unidade Nacional"

A Bacia Hidrográfica do Rio São Francisco de 1940 até o Presente (2007):

A Interação entre o Meio Ambiente, Governo, Leis, e Cidadãos.

I. INFORMAÇÕES SOBRE A ENTREVISTA

A. Hora:_____ B. Data: _____
C. Local:_____
D. Entrevistador:_____

II. INFORMAÇÕES SOBRE O PARTICIPANTE

A. Nome: _____
B. Título e/ou Posição Profissional: _____
C. Endereço: _____
D. Telefone: _____
E. E-mail:_____

III. PAPEL DO ENTREVISTADO E HISTÓRIA DE ENVOLVIMENTO COM ASSUNTOS RELACIONADOS A RECURSOS HÍDRICOS

A. Antes da sua participação com o caso do Rio São Francisco, qual o papel que você já desempenhou em relação à administração de outros rios/recursos hídricos?

B. Como o seu envolvimento começou?

C. Qual o papel que você já desempenhou, no passado, em relação a administração dos recursos e dos usos do Rio São Francisco?

D. Como começou?

E. Qual o papel que você atualmente desempenha em relação a administração do rio e dos recursos do São Francisco?

F. Como isso começou?

G. Hoje em dia, você participa da administração de outro rio/recursos hídricos, além do Rio São Francisco, por exemplo outro comitê ou outro rio? Qual?

H. Se participa, como começou?

I. O que o Rio São Francisco significa para você?

J. Como deve ser utilizado?

IV. PERSPECTIVA DO ENREVISTADO SOBRE OS FATOS

A. O que você sabe sobre o Comitê da Bacia Hidrográfica do Rio São Francisco? Qual o papel que o comitê tem que desempenhar?

B. Na sua opinião, o comitê é impotante?
   a. Sim ( ). Como/porque?
   b. Não ( ). Porque não?

C. Quais as atividades o comitê tem de fato desempenhado?

D. Como a administração do Rio São Francisco e seus recursos hoje, com a existência do comitê, difere da forma de administração anterior?

E. O que tem sido feito e occorido de forma diferente?

F. O novo comitê é importante para o São Francisco e o meio ambiente da bacia em geral?
   a. Sim ( ). Como?Você pode citar algum exemplo?
   b. Não ( ). Porque não?

G. O novo comitê é importante para as pessoas que vivem na bacia?
   a. Sim ( ). Porque? De que forma?
   b. Não ( ). Porque não?

H. O comitê tem causado algum impacto/influência na maneira em que as pessoas utilizam os recursos do Rio São Francisco? Quais pessoas (local, regional, national)?
   a. Sim ( ). Como?
   b. Não ( ). Porque não?

I. Quais são os objetivos do comitê?

J. Na sua opinião, quais são os desafios?

K. Se você pudesse, você mudaria alguma coisa no comitê?
   a. Sim ( ). O que?
   b. Não ( ).

L. Você acha que o comitê tem a autoridade e/ou habilidade e/ou recursos para mudar a situação atual do Rio São Francisco?
   a. Sim ( ). Como?
   b. Não ( ). Porque não?

M. Você acha que os resultados do trabalho do comitê conseguirão mudar as condições da bacia hidrográfica do São Francisco?
   a. Sim ( ). Como?
   b. Não ( ). Porque não?

N. Quem são os principais indivíduos ou groupos envolvidos no comitê?

O. O que eles têm feito?

P. Na sua opinião, o comitê faz algum esforço para incluir todos os grupos ou as preocupações de todos os grupos que deveriam estar participando?
   a. Sim ( ).
   b. Não ( ). Se não, quem está faltando?
      Como o grupo poderia ser representado?
      Porque a partipação desse indivíduo ou grupo é importante?

Q. Na sua opinião, qual o papel que o governo e as leis federais e estaduais desempenham em relação a administração do Rio São Francisco e da bacia hidrográfica?
   a. Você pode citar algum exemplo?

R. O governo federal e estadual estão coordenando esforços? Como? Estão dividindo custos?

S. O governo federal e estaduais estão coordenados com a administração de recursos hídricos fora do comitê? Como?

T. Como estão os ambientalistas/grupos de ambientalistas/entidades não-governamentais envolvidos nas decisões sobre a administraçao do São Francisco e dos recursos do rio?

U. Na sua opinião, a participação dos cidadãos em questões relacionadas ao Rio São Francisco mudou após a criação do comitê da bacia?
   a. Sim ( ). De que maneira?
   b. Não ( ).

V. Na sua opinião, a participação dos cidadãos no comitê é efetivo?
   a. Sim ( ). Como ocorre?
   b. Não ( ). Caso contrário... O que está faltando?
      O que poderia ser feito? Como?
      Por quem?

W. Você gostaria de acrescentar mais alguma coisa?

APPENDIX D1. FOCUSED INTERVIEW FORM: ECOLOGICAL AND SOCIAL CHANGES UNDER THE VIEW OF LOCAL POPULATION OF THE SFRB

The Long Journey to Become the 'River of National Unity'

The São Francisco River Basin from 1940 to Today: the Interactions of Environment, Government, Law, and Citizens.

I. INTERVIEW INFORMATION

A. Time:_____ B. Date:_____
C. Place:_____
D. Interviewer:_____

II. PARTICIPANT INFORMATION

A. Name:_____
B. How can I get in touch with you again? _____
_____

III. ASSESSMENT OF INTERVIEWEE AND ENVIRONMENT RELATIONSHIP

A. For how long have you been around the river? _____
   a. As a child?
      i. Yes ( )
      ii. No ( )

   b. As an adolescent?
      i. Yes ( )
      ii. No ( )

   c. As an adult?
      i. Yes ( )
      ii. No ( )

B. Do you live around here?
   a. Yes ( ). If so, for how long? _____
   b. No ( )

C. What do you do for living now?

D. For how long have you been doing that?

E. Have you done something else?
   a. What?

b. For how long?
c. Why did you change activity?

F. How did your grandparents use the river?

G. How did your grandparents speak about the river?

H. How did your parents use the river?

I. How did your parents speak about the river?

J. How do you use the river?

____ Drink the water

____ Live on its banks

____ Swim in it

____ Use it to transport people/commodities

____ Use its water for industrial purpose

____ Other (be specific):
_____

_____

____ Aesthetic enjoyment

____ Fish the waters. What do you fish?

____ Enjoy wildlife living along it

____ Use its water for agricultural purpose/to supply animal herds

____ Use its water for sewage disposal/What does this city do with the sewage? And garbage?

____ Use its water for electricity generation? Does your house have electrical power? From where does it come from?

IV. INTERVIEWEE ASSESSMENT ON THE ECOLOGICAL CHANGE

A. During the time you have lived and or worked here have you seen any changes?
   a. Which?
   b. Describe?

B. Have you noticed changes in the river?
   a. How? Which?
   b. Describe?

C. Indicators[1]: Have you seen any change....?

1. Visible Pollution such as debris _____
2. Restrictions on fish and wildlife consumption _____
3. Tainting of fish and wildlife _____
4. Degradation of fish or wildlife populations _____
5. Fish tumors or other deformities _____
6. Bird or animal (including humans) deformities or reproduction problems _____
7. Degradation of benthos _____
8. Need of or restrictions on dredging activities _____
9. Water level (lower/higher)
10. Eutrophication or undesirable algae _____
11. Exotic species (plants and animals/fishes which didn't exist here before) _____
12. Presence of Species which live/multiply in 'dirt' water (e.g., aquatic vegetation such as *baronesas* which reproduce fast in nutrient rich and calm waters)
13. Threatened/Endangered Species (species that doesn't exist anymore here) _____
14. Restrictions on drinking water consumption, or taste or odor problems _____
15. Beach closings _____
16. Degradation of aesthetics _____
17. Added costs to agriculture, industry, government and general public _____
18. Degradation of phytoplankton and zooplankton population _____
19. Loss of fish and wildlife habitat _____
20. Chemical concentration in soil, on water, and in the river bottom's sediments _____
21. Thermal pollution _____
22. Air pollution _____
23. Water-related diseases in humans _____

Other _____

_____

_____

[1] Sources: Modified from International Joint Commission (1989). Revised Great Lakes Water Quality Agreement. Ottawa, Canada: Office Consolidation: 31. M. L. Becker (1996). "A Contextual Map of the Remedial Action Policy Process." Implementing a Binational Ecosystem Strategy in the Great Lakes Basin. Ann Arbor: UMI: 189. Nascimento, Luci. "Assessing Progress toward Ecological Sustainability in the Hudson River Ecosystem (NY) through Citizen Participation." Thesis, New Hampshire, 2003.

_____

_____

V. INTERVIEWEE ASSESSMENT ON THE PEOPLE AND ENVIRONMENT RELATIONSHIP

A. In your opinion, in what ways did people here interact with the São Francisco River in the past?

____ Drank the water

____ Lived on its banks

____ Swam in it

____ Used it to transport people/commodities

____ Used its water for industrial purpose

____ Other (be specific): _____

____ Aesthetic enjoyment

____ Fished the waters/What did they fish?

____ Enjoyed wildlife living along it

____ Used its water for agricultural purpose/to supply animal herds?

____ Used its water for sewage disposal/What did the city do with sewage? And garbage?

____ Used its water for electricity generation? Did they have electric power? From where did it come from?

B. From your perspective, has this interaction changed over time?

a. Yes( ) No( ) If yes, How?

C. In your opinion, in what ways do people here interact with the São Francisco River in the present?

____ Drink the water

____ Live on its banks

____ Swim in it

____ Use it to transport people/commodities

____ Use its water for industrial purpose

____ Aesthetic enjoyment

____ Fish the waters/What?

____ Enjoy wildlife living along it

____ Use its water for agricultural purpose/to supply animal herds?

____ Use its water for sewage disposal/garbage?

____ Other (be specific): _____

____ Use its water for electricity generation

VI. INTERVIEWEE ASSESSMENT ON THE RIVER AND RIVER BASIN MANAGEMENT

A. What has the government been doing right? What government?

B. What has the government been doing wrong? What government?

C. What have people been doing right?

D. What have people been doing wrong?

E. How should the government manage the river?

F. If you were chose to manage the river, what would you do? How?

G. Have you ever participate in any form of project for the management of the SFR or basin? When? How? Where? How did that work?

H. Would you like to add anything else?

APPENDIX D2. FORMULÁRIO PARA ENTREVISTA INDIVIDUAL: MUDANÇAS ECOLÓGICAS SOB A ÓTICA DAS POPULAÇÕES LOCAIS

A Longa Jornada até transfomar-se no "Rio da Unidade Nacional"

A Bacia Hidrográfica do Rio São Francisco de 1940 até o Presente (2007):

A Interação entre o Meio Ambiente, Governo, Leis, e Cidadãos.

I. INFORMAÇÕES SOBRE A ENTREVISTA

A. Hora:_____ B. Data:_____
C. Local:_____
D. Entrevistador:_____

II. INFORMAÇÕES SOBRE O (A) ENTREVISTADO(A)

A. Nome:_____
B. Onde posso encontrá-lo(a)? _____
_____

III. RELACÃO ENTRE O ENTREVISTADO E O MEIO AMBIENTE

A. Há quanto tempo você tem contato com o rio? _____
   a. Quando era criança?
      i. Sim ( )
      ii. Não ( )
   b. Quando era adolescente(mais jovem)?
      i. Sim ( )
      ii. Não ( )
   c. Como adulto?
      i. Sim ( )
      ii. Não ( )

B. Você mora aqui por perto?
   a. Sim ( ). Há quanto tempo? _____
   b. Não ( )

C. Você faz o quê?

D. Há quanto tempo trabalha nisso?

E. Você já fez outro trabalho?
   a. O quê?
   b. Por quanto tempo?

c. Porque voce mudou de atividade?

F. Como os seus avôs usavam/usam o rio?

G. O quê eles falavam/falam sobre o rio?

H. Como os seus pais usavam/usam o rio?

I. O que os seus pais falavam/falam sobre o rio?

J. Como você usa o rio?

____ Bebe a água do rio?

____ Mora na beira/nas margens do rio?

____ Nada no rio?

____ O rio é um meio de transporte para você? Para mercadorias?

____ Usa o rio para indústrias, fábricas?

____ Você se lembra de alguma outra coisa que você faz no rio? Ou com o rio? Ou com as coisas que tira do rio?

_____

____ Se distraí olhando o rio?

____ Pesca?
Pesca o quê? _____

____ Se distraí olhando os bichos que vivem no rio?

____ Usa o rio para agricultura/plantar? Usa o rio para dar de beber aos bichos?

____ Usa o rio para jogar esgoto? Essa cidade joga o esgoto onde?E o lixo?

____ Na sua casa tem luz elétrica? A sua luz vem de onde?

IV. MUDANÇAS ECOLÓGICAS NA OPINIÃO DAS POPULAÇÕES LOCAIS

A. Durante o tempo que você tem morado ou trabalhado aqui alguma coisa mudou?
   a. O quê?
   b. Fale mais um pouco sobre isso?

B. O Rio São Francisco mudou?
   a. Como? O quê?
   b. Fale mais um pouco sobre isso?

C. Indicatores[1]: Você notou alguma mudança...?

1. Tem alguma coisa diferente com a água do rio? _____
2. Alguém disse que não é bom comer algum tipo de peixe ou de bicho? Qual? Quem falou? _____
3. Tem alguma coisa/contaminação no peixe ou nos outros animais, como por exemplo, nos bichos que vocês caçam? _____
4. Destruição/mortalidade de peixes e de outros animais? _____
5. Tumor ou outra deformidade em peixes? Algum peixe torto/doente? _____
6. Algum problema com os passaros ou outros animais, por exemplo, seres humanos? _____
7. Destruição dos animais que vivem no fundo do rio? _____
8. Existe necessidade de dragar ou não pode por causa de poluição concentrada no fundo do rio? _____
9. Nível da água (alto/baixo)
10. Eutrofização artificial/algas indesejavéis _____
11. Espécies exóticas (tem alguma planta ou bicho que não existia aqui antes?) _____
12. Tem alguma espécie aqui que aparece/vive em água suja (e.g., *baronesas* que se reproduz em água calma e cheia de nutrientes) _____
13. Espécies em perigo/ameaçadas de extinção _____
14. Proibição no consumo de água, relativo a problemas de contaminação, ou presença de sabor e odor _____
15. Fechamento de praia por motivo de contaminação/aviso de contaminação _____
16. Destruição da beleza natural _____
17. Aumento de custo para a agricultura, industria, governo e população em geral (aumento de custo para tratamento da água) _____
18. Destruição de fitoplâncton(algas) e zooplâncton (pequenos animais) _____
19. Destruição do habitat para peixes e outros animais _____
20. Concentração de produtos químicos no solo, na água, e em sedimentos _____
21. Poluição térmica _____
22. Poluição do ar _____
23. Doenças causadas pela água _____

[1] Fontes: Modificado de International Joint Commission (1989). Revised Great Lakes Water Quality Agreement. Ottawa, Canada: Office Consolidation: 31. M. L. Becker (1996). "A Contextual Map of the Remedial Action Policy Process." Implementing a Binational Ecosystem Strategy in the Great Lakes Basin. Ann Arbor: UMI: 189. Nascimento, Luci. "Assessing Progress toward Ecological Sustainability in the Hudson River Ecosystem (NY) through Citizen Participation." Thesis, New Hampshire, 2003.

Outros _____

V. RELACÃO ENTRE SER HUMANO E MEIO AMBIENTE NO PASSADO

A. Na sua opinião, de que maneira as pessoas daqui interagiam com o Rio São Francisco no passado?

____ Bebia a água do rio?

____ Morava na beira do rio?

____ Nadava no rio?

____ O rio era meio de transporte para gente? Para mercadorias?

____ Usava o rio para indústrias, fábricas?

____ Você se lembra de alguma outra coisa que eles faziam no rio? Ou com o rio? Ou com as coisas que tiravam do rio? _____

____ Se distraía olhando o rio?

____ Pescava?
Pescava o quê? _____

____ Se distraía olhando os bichos que vivem no rio?

____ Usava o rio para agricultura/plantar? Usava o rio para dar de beber aos bichos?

____ Usava o rio para jogar esgoto? Essa cidade jogava o esgoto onde? E o lixo?

____ Na casa deles tinha luz elétrica? A luz vinha de onde?

B. Na sua opinião essa relação com o rio tem mudado com o tempo?

a. Sim( ) Não( ) Se afirmativo, como?

C. No seu ponto de vista, de que maneira as pessoas interagen/ se relacionam com o Rio São Francisco agora (no presente)?

____ Bebe a água do rio?

____ Mora na beira do rio?

____ Nada no rio?

____ O rio é meio de transporte para gente? Para mercadorias?

____ Usa o rio para indústrias, fábricas?

____ Você se lembra de alguma outra coisa que faz no rio? Com as

____ Se distraí olhando o rio?

____ Pesca?
Pesca o quê?
_____

____ Se distraí olhando os bichos que vivem no rio?

____ Usa o rio para agricultura/plantar? Usa o rio para dar de beber aos bichos?

____ Usa o rio para jogar esgoto? Essa cidade joga o esgoto onde? E o lixo?

____ Na casa deles tem luz elétrica? A luz vem de onde?

coisas que tira do rio?

VI. ADMINISTRAÇÃO DO RIO E DE SEUS RECURSOS

A. O que o governo tem feito certo? Que governo?

B. O que o governo tem feito de errado? Que governo?

C. O que as pessoas estão fazendo certo?

D. O que as pessoas estão fazendo de errado?

E. Como o governo deveria administrar o uso do rio e dos seus recursos?

F. Se você fosse escolhido para administrar o uso do rio e dos seus recursos, o que você faria? Como?

G. Você já participou em alguma forma de administração dos recursos do RSF e dos seus recursos e da bacia? Quando? Como? Onde? Como funciona?

H. Você quer falar mais alguma coisa?

APPENDIX E1. SFRB COMMITTEE MEETINGS: OBSERVATION FORM

The Long Journey to Become the 'River of National Unity'

The São Francisco River Basin from 1940 to Today: the Interactions of Environment, Government, Law, and Citizens.

ACCESSIBILITY OF THE MEETING

DATE: _____

TIME: _____

LOCAL: _____

WHO ORGANIZED THE MEETING? _____

HOW WAS THE MEETING ADVERTISED? _____

_____

HOW WAS ACCESS GRANTED? _____

_____

WAS THE MEETING ACCESSIBLE (TRANSPORTATION/LOCAL/TIME)? _____

_____

PARTICIPANTS

OBSERVER: _____

TIME OBSERVER ARRIVED: _____

TIME OTHER PARTICIPANTS ARRIVED: _____

_____

NUMBER OF PARTICIPANTS PRESENT: _____

WHO DO THEY REPRESENT? _____

_____

THE MEETING

WHO WILL RUN THE MEETING? _____

OBJECTIVE OF THE MEETING: _____

SETUP OF ROOM:

INITIAL DYNAMIC (BEFORE BEGINNING OF THE MEETING): _____

TIME MEETING ATUALLY STARTED: _____ TIME MEETING ENDED: _____

THE MEETING:

APPENDIX E2. FORMULÁRIO PARA OBSERVAÇÃO DOS ENCONTROS DO COMITÊ DA BACIA HIDROGRÁFICA DO RIO SÃO FRANCISCO

A Longa Jornada até transfomar-se no "Rio da Unidade Nacional"

A Bacia Hidrográfica do Rio São Francisco de 1940 até o Presente (2007):

A Interação entre o Meio Ambiente, Governo, Leis, e Cidadãos.

ACESSO AO ENCONTRO

DATA: _____

HORA: _____

LOCAL: _____

QEM ORGANIZOU O ENCONTRO? _____

COMO O ENCONTRO FOI ANUNCIADO (IMPRENSA)? _____

_____

COMO O ACESSO FOI GARANTIDO? _____

_____

O ENCONTRO FOI ACESSÍVEL(TRANSPORTE/LOCAL/HORA)? _____

_____

PARTICIPANTES

OBSERVADOR: _____

HORA EM QUE O OBSERVADOR CHEGOU: _____

HORA EM QUE OS OUTROS PARTICIPANTES CHEGARAM: _____

_____

NÚMERO DE PARTICIPANTES PRESENTE: _____

A QUEM ELES REPRESENTAM? _____

_____

O ENCONTRO

QUEM VAI CHEFIAR O ENCONTRO? _____

OBJETIVO DO ENCONTRO: _____

ORGANIZAÇÃO DA SALA DE REUNIÃO:

DINÂMICA INICIAL (ANTES DO INÍCIO DO ENCONTRO): _____

HORA EM QUE O ENCONTRO TEVE INÍCIO:_____ HORÁRIO DE ENCERRAMENTO:_____

O ENCONTRO: