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Water Resources Development in the São Francisco River Basin (Brazil): *Conflicts and Management Perspectives*

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Abstract: *Water scarcity is matter of growing concern in Brazil, especially in the semi-arid, inland area of the Northeast, where the São Francisco River flows. This paper concentrates on the relations between the concrete experience of water resources development and the remaining demands for efficient water management in that river basin. The emphasis is on its Sub-Middle section, which since 1948 has been the preferential area for irrigation projects and hydropower generation. Recent modifications in the Brazilian legislation provide for a new approach to water resources policy, which is in favor of more decentralized and proactive forms of water management. In spite of such institutional evolution, conservative political groups in the São Francisco River Basin have put obstacles before the transformation of established practices. In addition, there are other structural limitations contributing to hinder the adoption of a more comprehensive framework of water management. Resulting water conflicts have raised increasing demands for proper attention to the social, economic and environmental requirements of the sustainable management of water. The requisites for that go beyond the water question itself because they involve broader political and socio-economic controversies. At the local level, priority must be given to measures aimed at achieving water efficiency and conservation. It is fundamental to address the reduction of human vulnerability to climatic risks and to adopt alternatives of better utilization of water resources.*

Keywords: *Brazilian Northeast, São Francisco River, water development, irrigation, hydropower*

Introduction

This case study discusses the human dynamic around water in the São Francisco River Basin, Brazil, looking to the future with lessons from the past. It is taken for granted that sustainability is the main goal of environmental management and, consequently, it should underpin development policies and programs. As an operational definition, the present discussion heuristically considers sustainable water management at the river basin level as:

> A continuous process of managing river basin natural and artificial resources, considering the human dependency on the cyclical flow of water as implication for integrated efforts and environmental stewardship.

The following sections examine the origins of the local water development problems, reasons for improving water management, and alternatives to attempt sustainable water manipulation that simultaneously contribute to strengthen equity and social justice, which complement or amplify the environmental goals (Lélé, 1999). The river basin context is briefly described in the first section with supportive arguments for a more comprehensive water management that seems to be needed. Water development is understood under the perspective proposed by Dourojeanni (1994). According to this author, Latin America has had successive stages in the process of dealing with water: (1) water resources development (hydraulic constructions); (2) water resources management (administration of water uses); (3) river basin development (regional development); (4) watershed management (especially involving pollution and soil erosion control); and (5) environmental management (multiple management of the river basin resources). In the São Francisco River Basin (SFRB), few of those stages have occurred concomitantly, but without a coordinated framework of actions.

The Experience of Water Resources Development in the Sub-Middle São Francisco River Basin

The Sub-Middle of the São Francisco River Basin

The interior of the Northeast region of Brazil is a large water-scarce backland area, which is administratively described as the Drought Polygon. Skidmore (1999) notes that since the 19th Century the backland has been in economic decline and "the result has been continuing poverty for the population, which now constitutes the largest pocket of misery in the Americas" (p. 4). Water scarcity has fundamental natural causes there such as:

extensive crystalline terrenes, annual oscillation of the Inter-Tropical Convergence Zone (ITCZ) and cyclical El Niño events. Likewise, all these natural processes have been aggravated by widespread human impacts on the regional geography. The São Francisco River Basin has 58 percent of its area lying within this Northeastern Drought Polygon. Despite that, there is relatively high water availability in the São Francisco River due to flows coming from its upper reaches in the center of the country. Moreover, water in SFRB is very unevenly distributed over time and space, and most of the catchment population depends on rainfed agriculture and groundwater supply. According to the demographic census of 1991 of IBGE, the population in the backland zone of SFRB was 4,996,772 persons, being 2,213,236 in cities and 2,783,536 in rural areas. Only around 70 percent of urban and 20 percent of rural residences have connections with public freshwater supply systems.

One of the four subdivisions of SFRB is its Sub-Middle section, which consists of approximately 390,000 km^2 in the Brazilian states of Bahia and Pernambuco, entirely within the Drought Polygon (Figure 1) and extending from Sobradinho Reservoir until Paulo Afonso Falls (Figure 2). The Sub-Middle has a tropical semi-arid climate with the following characteristics (CODEVASF, 1989): mean precipitation is 350–600 mm/year and the rainy season is from November to April; mean temperature is around 26.5 degrees Celsius; and potential evaporation is about 3,000 mm/year (implying significant annual water deficits). Considering the local rainfall, 84 percent evapotranspirates (or evaporates), 11 percent goes to the watercourses, and 5 percent recharges the aquifers. River gradient in the Sub-Middle is 0.10–0.30 m/km and there is significant annual oscillation of the river flow (Figure 3). Caatinga (scrub savanna) is the predominant vegetation. Altitude in this sub-catchment oscillates from 200 to 500 m. There are no perennial tributary rivers in this part of the basin.

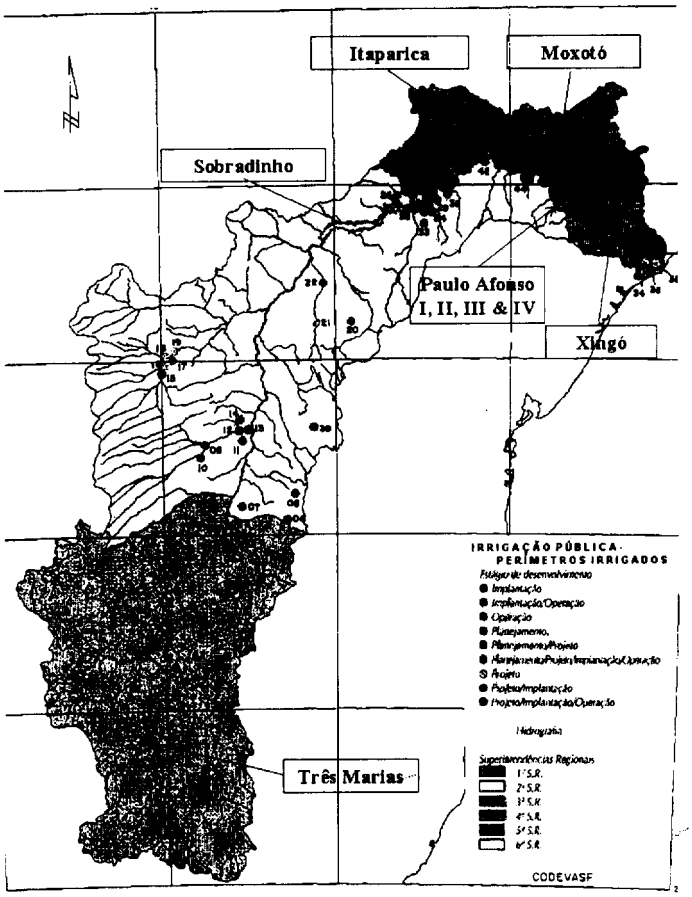

Figure 2. Irrigation districts (points indicated in the map) and major hydropower plants.

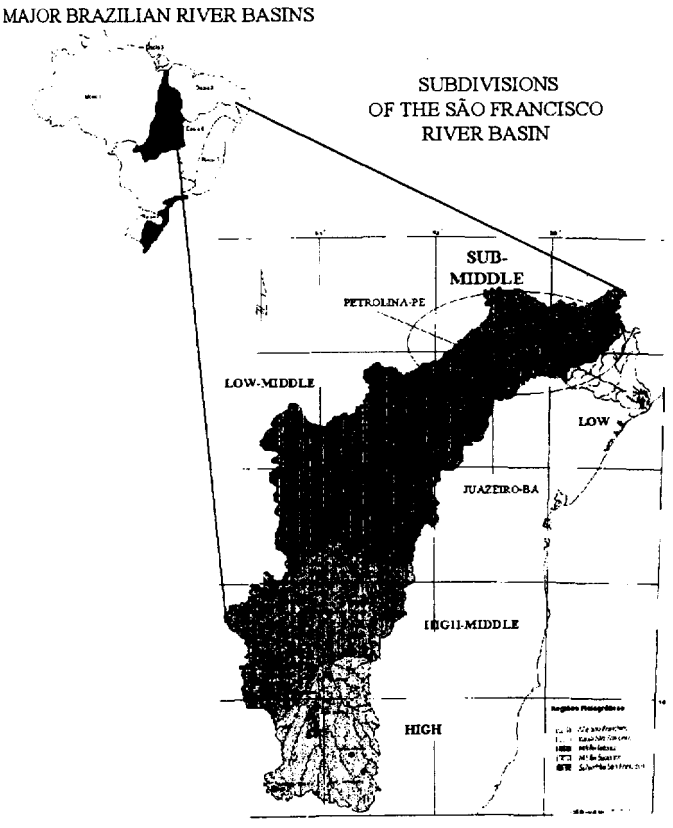

Figure 1. SFRB Situation in Brazil and its subdivisions.

The most significant feature of the semi-arid climate of the Brazilian Northeast is its variability. Annually, a long dry period is proceeded by a few months of intense precipitation. In addition to this seasonal variation, after a sequence of typical years a period of drought may occur, when the region can remain for three or more years without regular rains. Duque (1973) [in Ponce, 1995] states that daily variability may be even more marked, concluding that "a drought year in the backland may be a year where it rains about half of the annual rainfall in just one month, and about half of that month's rainfall in just one day." For instance, the city of Petrolina, in the Sub-Middle, recorded the mean precipitation of 433.8 mm per year in the 20th Century, with a significant coefficient of varia-

tion of 164.3 mm. In 1951, the driest year of the century, precipitation was only 174.0 mm in Petrolina (Gasques et al., 1995). In the drought year of 1998 alone, the state of Bahia had 90 affected municipalities (impacting 2,168,421 inhabitants) and the state of Pernambuco had 69 municipalities (1,614,565 inhabitants), according to SUDENE (1999) [in CODEVASF, 1999].

The São Francisco River is sometimes called "the Brazilian Nile," because, like its African counterpart, it is a long river crossing dry areas and raising hope. The comparison is not really proper though, because geographic and historic features are substantially diverse. It has also been traditionally denominated the river of an alleged "national unification," because it has been theatre for social, environmental and ethical contentions to tame the semi-arid backlands in the last five centuries of Brazilian history. However, simple claims for unification are something rather ideological when raised in such an unstable and excluding society where natural and artificial resources have been appropriated by small dominant groups. The principal local beneficiaries of the water development in the Sub-Middle SFRB are members of the regional oligarchy, which is basically composed of large landowners that strongly influence, for example, the administration of public irrigation districts, the operation of development agencies and banks, and the expansion of urban and rural water distribution. Due to the intricacies of Brazilian political alliances, these groups can greatly interfere with federal actions of water control in SFRB, reinforcing and maintaining the same social and political reality.

Water Utilization in the Sub-Middle of SFRB

The most important economic sectors in the Sub-Middle are irrigation and hydropower, both heavily relying on water resources. Water is also used in SFRB for

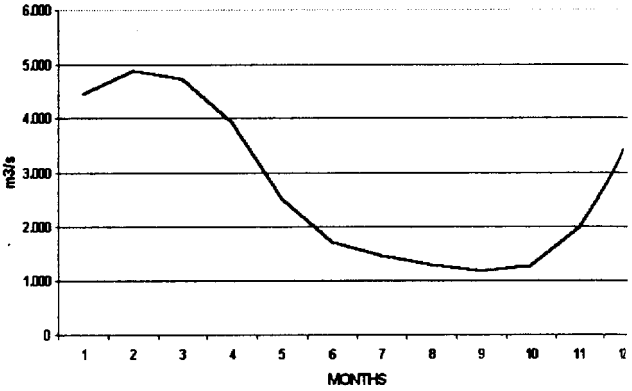

Figure 3. Oscillation of the São Francisco mean flow in the s middle section of the basin (Juazeiro, State of Bahia).

domestic and industrial supply (i.e., all consumptive us but agriculture and household), dilution of domestic a industrial waste, watering of animals, waterway transpo wildlife preservation, recreation, and fishing (Table Freshwater supply and sanitation use only a small fracti of the total volume of water.

Responsible for three-fourths of the water consum irrigation is seen as a combination of production, drou control, and poverty alleviation in SFRB. Remarkably was only after the 1960s that irrigation started to be co sidered as an effective technical solution (Table 2). retrospect it is surprising in some ways that irrigation an anti-drought tactic was not more widely adopted e lier on" (Hall, 1978). The reluctance to make earlier i of irrigation had two basic causes. First, the expansion irrigation would necessarily rearrange land occupati and this was strongly resisted by powerful landowne Second, water development was only seen as an additi to the amount of water stored and the expansion of hyd

Table 2.

Evolution (until the year)	*B*
1950	
1960	
1970	
1975	1,
1980	1,
1985	1,
1990	2,
1994	
1995	
1996	
Until 1997	

Source: CODEV

power genera sisted.

Interestin a dual situati geography. C upstream wat flow is contri cent is approx of the total ri other hand, th downstream, ergy and the p the Sub-Midd rigation expan from 1970 to perienced stea

Table 1. Water Demand in the Northeast Region and in the São Francisco River Basin

	Northeast Region			*SFRB*		
Use/Demand	*Annual Demanded Volume (billion m³)*	*Relation to the Total (%)*	*Relation to the Consumption (%)*	*Annual Demanded Volume (billion m³)*	*Relation to the Total (%)*	*Relati to the Consumpti (%)*
Consumptive Uses	12.6	57.5	100.0	2.7	29.7	100.0
Irrigation	6.2	28.3	49.3	2.0	22.0	74.1
Urban Uses	3.0	13.7	23.7	0.3	3.3	11.1
Agro-industry	1.3	5.8	10.1	0.1	1.1	3.7
Livestock	0.9	4.3	7.4	0.2	2.2	7.4
Industrial Uses	0.8	3.4	5.9	0.1	1.1	3.7
Diffuse Rural Consumption	0.4	2.0	3.5	0.0	0.0	0.0
Non-consumptive Uses (including hydropower)	9.3	42.5	-	6.4	70.3	-
Total	21.9	100.0	100.0	9.1	100.0	100.0

Source: ARIDAS Project (1995)

Project
Bebedouro I
Mandacaru
Tourão
Bebedouro II
Maniçoba
Curaçá
Nilo Coelho

*S: Small; M: Me
Adapted from Sai

Table 2. Comparative Evolution of Irrigation in SFRB (thousands of hectares)

Evolution (until the year)	*Brazil*	*Northeast*	*SFRB*	*CODEVASF*
1950	0.1	0.1	0.1	0.1
1960	461.6	28.6	10.8	1.1
1970	795.8	116.0	60.2	2.3
1975	1,086.8	163.4	88.0	12.1
1980	1,481.2	261.4	144.5	27.0
1985	1,853.7	335.8	205.9	47.9
1990	2,911.7	732.5	232.6	67.0
1994	-	-	250.0	71.8
1995	-	-	300.0	72.8
1996	-	-	-	79.7
Until 1997	-	-	-	91.2

Source: CODEVASF (1999)

power generation, not by water conveyed or people assisted.

Interestingly, the Sub-Middle segment of SFRB has a dual situation concerning its position in the watershed geography. On one hand, it is greatly dependent upon upstream waters, since only 2.5 percent of the total river flow is contribution of this segment of the basin (2.5 percent is approximately 80 m^3/s) and more than 70 percent of the total river flow comes from upper reaches. On the other hand, the Sub-Middle is strategically important to downstream, coastal cities as the supplier of hydro-energy and the producer of tropical exportable crops, since the Sub-Middle is where most of the hydropower and irrigation expansion has taken place in SFRB. For instance, from 1970 to 1992 a few local agriculture poles have experienced steady economic growth, grounded on the expansion of irrigated areas, introduction of large hydraulic constructions and circulation of capital (Gomes and Vergolino, 1995), but have stabilized since then due to constraints in governmental investments (Table 3).

Institutional Evolution of the Water Resources Development of SFRB

Water allocation has raised considerable regional expectations in SFRB, where "the tapping of relatively scarce hydrological resources (...) has been perceived as an increasing important means of promoting economic growth" (Redwood, 1993:47). After World War II, the influence of the Tennessee Valley Authority inspired the establishment of a new federal agency in 1948, the Commission of the São Francisco Valley (CVSF), which was specifically aimed at the development of the river basin itself. However, the policy of river basin development did not benefit from sufficient time or political stability to achieve full execution. Under military authoritarian administrations in Brazil (1964–1985), profound changes in the orientation of national policies led, in 1967, to the conversion of CVSF into a new agency: the Superintendency of the São Francisco Valley (SUVALE). Basically, the river basin management of CVSF was limited to more focused interventions, particularly public irrigation districts. Failings and new demands led to another adjustment in 1974, when SUVALE was transformed into a more autonomous institution: the Company for the Development of the São Francisco Valley (CODEVASF), still the development agency of SFRB to date. Under the coordination of CODEVASF, public irrigation projects have been implemented and further private entrepreneurs received incentives to operate inside or outside public irrigation schemes.

Table 3. Main Irrigation Projects in the Sub-Middle of the São Francisco Valley

Project	*Establishment*	*Total Area (ha)*	*Irrigable Area (ha)*	*Pumping Capacity (m^3/s)*	*Area Individual Farmers*			*Area of Companies*	
					Lot	*Area (ha)*	*Average*	*Number of Lots**	*Area (ha)*
Bebedouro I	1968	7,797	2,418	3.7	104	1,090	10.5	6	1,328
Mandacaru	1973	823	382	0.72	331	331	6.5	1	51
Tourão	1976	10,713	10,454	11.06	32	182	5.7	M = 17 L = 2	2,034 8,238
Bebedouro II	1981	2,064	667	-	-	-	-	1	2,064
Maniçoba	1981	12,236	4,317	5.43	232	1,890	8.1	S&M=50 L=1	1,321 500
Curaçá	1982	15,059	4,436	5.66	267	1,964	7.3	16	2,280
Nilo Coelho	1984	56,286	20,018	23.2	1,432	8,590	6.0	S&M=105 L=8	12~59/lot 60~320/lot

*S: Small; M: Medium; L: Large

Adapted from Saito and Yagasaki (1995)

Presently, one in every four irrigated hectares is located in public districts in SFRB. Simpson (1999) observes that CODEVASF has produced inefficient, large irrigation projects, but without federal investments the irrigation expansion in SFRB would not have developed. The policy of CVSF was to stimulate small farm irrigation along riverbanks and to support various other local interventions. SUVALE mainly achieved irrigation through public projects, while CODEVASF gave rise to private business and large-scale irrigation. Yet in the year 1948, the agency in charge of hydroelectricity generation in SFRB, the São Francisco Hydroelectric Company (CHESF) was created, and was responsible for most of the major engineering constructions in the river basin.

Institutional Challenges for Sustainable Water Management

The observation that "the middle São Francisco Valley has been one of the 'problem' areas of Brazil" (Wythe, 1949:157) is certainly not new. Since the 1940s, SFRB has become a preferential area for the expansion of both hydropower generation and irrigated agriculture, but it still did not achieve a level of effective water resources management. Federal and state agencies are fundamental parties in this operation, but they are not used to working together on the river basin problems. The predominant form of government action has been isolated interventions with limited stakeholder involvement. There have also been practical limitations regarding the mitigation of social and environmental impacts. Likewise, several water development plans have been formulated since 1948, but they have had more historical significance than they have offered any real solution for the management of water. That is because plans and policies have normally been only partially implemented and scantily observed. Furthermore, the large number of plans indicates a serious lack of continuity. Frequently, efforts entailed by a governmental agency during an individual presidential mandate are interrupted by the next administration. In addition, there is constant dissociation between the planning process and the decision-making. There is a generalized demand for better qualified human resources, particularly water management facilitators.

The New Brazilian legislation of 1997 sets up novel instruments of water management, such as basin committees, award of water permits, and charges for bulk water use and effluent discharges. The reflexes of this law led in SFRB to the elaboration of master plans in 70 percent of the São Francisco tributaries. But there is not yet a comprehensive plan of the whole basin and just a few tributaries have created their basin committees (Santos, 1999). Even the novelty of the new legal framework, previous and present institutions face challenges in incorporating new methodologies and contemporary demands. Supplementary adjustment to the adoption of water policy mechanisms are very much retarded, such as the coordination between federal and state boards and the harmonization between different legislation levels (i.e. in Brazil, water is matter of federal, state, and municipal law). Official agencies continue to operate isolated and without systematic consultation at the basin level. Centralization of decision-making in political centers outside the basin (e.g. Brasília, Recife, and Salvador) increases administrative expenses and gives rise to competition between public offices. The situation is one of overlap of functions, legal obstacles, inadequate institutional arrangement, lack of central coordination, lack of resources, and deficient linkage between water resources projects and development programs. Moreover, Kettelhut et al. (1998) make reference to the difficulties in terms of mobilization between government and society regarding water management in Brazil. The same authors also stress that the peculiarities of the Brazilian public affairs act as a hindrance to the implementation of basin plans, as long as river basin committees are expected to reduce the attributions of other governmental bodies, possibly provoking political clashes. More difficult than the design of new committees or ingenious water plans is to transform traditional management practices. "The negotiation process to resolve the conflicts created by an integrated management scheme for the Rio São Francisco will require a great level of consensus building and a strong participatory approach at all levels. (...) This challenge alone is formidable" (Simpson, 1998). The next part analyzes the basic causes of the water management problems in the semi-arid zone of SFRB.

The Origins of the Water Problems in the Semi-Arid SFRB

There are four key problems behind the apparent lack of sustainability in the use of water in the Sub-Middle SFRB: (1) the need for new ethical bases in the human relations with natural resources, to include the perception that the economy operates inside a non-expanding system, the environment; (2) the uneven form that different groups are affected by the water scarcity condition; (3) misconceived and inefficient interventions, basically reflecting the political control of governmental policies by strong landowner groups; and (4) open and unsolved conflicts between competitive uses of water.

Environment Impacts Without Adequate Treatment and Mitigation

The first fundamental claim to transform the established framework of appropriation and use of water in SFRB is the environmental dimension. Ecological threats have arisen with the ever-growing pressures for water in SFRB and due to the human transformation of natural landscapes. As in many other river basins in Latin America, there are in SFRB different human groups in different moments of "historical evolution," but facing

serious disputes to divide space and resources. The environment has been assigned only an unimportant "share" in water allocation, as if there were no limits for human activities involving water depletion, derivation, or pollution. However, the volume of environmental water demand is on a par with irrigation and is much larger than municipal and industrial needs (Turral, 1998).

There are still not enough data available to measure the exact depletion of natural resources in SFRB, but it is possible to infer that the ongoing reduction of natural capital will certainly hinder the economic possibilities of the next generations. The traditional approach has resulted in the threat of permitted environmental disruption on the grounds of the need of economic growth at any cost. At times of serious drought, the normal excuse is that SFRB is a needy area and then any ill-conceived intervention must be allowed in the rush to deal with the crisis. Effects on the local ecological equilibrium are evident, which include soil degradation, devegetation, evidences of desertification, biodiversity loss, and water pollution. A significant rate of impact is evident on fluv ial ecotones (due to deforestation, dam construction, water abstraction, and soil reclamation at the river meanders). There are major geomorphologic alterations along the riverbanks and increasing modification of flora and fauna. Particularly headwater degradation is very critical, because most of the water in SFRB comes from its upper reaches. Water monitoring has shown in many parts of the catchment excessive levels of organic matter, turbidity and sedimentation, coliform bacteria, oil and grease, iron, cadmium, lead, chromium, manganese, arsenic, phenol compounds, ammonia, and high pH. The main sources of pollution are mines and industries in the upper reaches, human settlements without sewerage treatment for effluents, and nonpoint agrochemical users in farms around the entire basin.

To cope with the widespread environmental degradation, a recent revitalization plan was prepared (MI, 2000) and involves US$ 750 million for a ten-year period. It includes: (a) strategic actions of water resources development (US$10 million); (b) organization of natural resources management institutions (US$35 million); (c) urgent environmental measures (US$29 million); (d) medium and long term environmental measures (US$104 million); (e) actions to improve water quantity and quality in SFRB (US$469 million); and (f) sector specific actions (US$103 million). The substantial figures of this plan demonstrate the serious level of environmental degradation already observed in SFRB.

Water Scarcity Aggravated by Social Exclusion

The prevalent form of water development in the Sub-Middle during the 20th century did not change the underlying, excluding social structure, which was established in the early 17th century. The most sensitive economic sector has traditionally been subsistence agriculture, and those most affected by droughts are impoverished social groups, who suffer even during minor rainfall oscillations. During dry periods, water supply becomes even more deficient and employment opportunities become less available. Drought acts as an "aggravating agent" which further depletes the already marginal rural productivity. Therefore, the primary economic adversity of semi-arid developing regions does not seem to be climatic variability, drought, soil erosion or floods, but the vulnerability of the population to the effects of these events.

Water availability, here taken as means for survival and economic organization, plays a fundamental role in the social organization of the Sub-Middle SFRB. The natural semi-aridity undoubtedly poses severe difficulties for human survival, but it is not the fundamental reason for underdevelopment and poverty, as usually stated by local political leaders. On the contrary, the main social and structural problem is the condition of serious wealth concentration, particularly in rural areas (Furtado, 1984). Consequently, the great majority of the rural population does not have any possibility of economic accumulation and just struggles to barely survive. Sen (1984) states that the difficulties of a specific community to survive during periods of penury and starvation are more related to low social organization or weak political representation than just to physical reasons.

Governmental initiatives implemented in this river basin did not intend to change land distribution pattern and have seldom, if ever, reduced drought vulnerability by providing water security to the majority of the population. For rainfed agriculture, the association between land ownership and better water provision is direct, because the principal groups affected during the droughts are exactly those that do not have formal property rights of their land. The consequences have routinely been low economic productivity, since most of the land is not cultivated and irrigated areas only represent a small fraction of the total. In public irrigation districts, subsistence production is not sufficient to permit small farmers to pay for all irrigation investments. Consequently, the extension of small irrigation systems is dependent upon subsidies and governmental incentives. That reduces the implementation rate of public irrigation in SFRB, and the use of irrigation on its own is, therefore, only a limited solution to promote water security. Falkenmark (1997a) notes that radical changes in agricultural policies are necessary for vulnerable areas, and indeed there are distinct potential methods to achieve drought proofing for agriculture other than using conventional irrigation.

Even in settlements very close to the river the reality is the same as one in the heart of the backland because the water development of SFRB has just served a very small proportion of the rural population. It becomes apparent that scarcity of water in the Northeast of Brazil is principally the outcome of bad management and waste of water. Even during dry years, the available water would be enough to satisfy human needs, if distribution and con-

servation were properly executed. Kelman (1997) stresses that "lack of hydraulic structures, lack of human resources and lack of proper institutions contribute to transform a natural phenomenon into a human disaster" in the semi-arid backland. The water scarcity condition has not been effectively addressed yet because it mainly affects deprived social groups. Livingstone and Assunção (1993) demonstrate the failure in promoting water solutions and how the traditional policy of water storage has been dominated by politicians, landowners, bureaucrats, and local and foreign construction companies. Furthermore, the dominant political group has various ways of safeguarding itself against dry periods and can accumulate even more capital during droughts by exploiting desperate people or controlling funds intended for emergency measures.

Misconceived and Inefficient Government Actions

In SFRB, most of the water development projects that have played a key role in the dramatic transformations in the last decades were point-interventions that did not produce long-term achievements. There are presently more than 80 individual programs concerning drought alleviation in the region, but they are neither coordinated nor integrated. For instance, in the year 2000, the Brazilian government was dealing with three international projects related to water development in SFRB (i.e., backed by the World Bank, the Interamerican Development Bank, and the Global Environmental Facility). However, there are (at best) tiny demonstrations of change in the traditional way of conducting studies and programs.

Tendler (1993) identifies problems in most of the local projects supported by the World Bank (i.e. most of the hydraulic constructions of SFRB have been financed by the Bank), not only during the implementation of those projects, but also at their conception stage, such as excessive complexity, lack of technical assistance for small farmers and the absence of beneficiary participation. Romano and Cadavid Garcia (1999) discuss manifold failures of government planning and interventions in the recent process of water development in SFRB, such as: (1) electric power generation has done little for the lands along the banks of the river, since most of the existing private irrigation schemes are oil-driven; (2) fluvial navigation has been interrupted because of the lack of maintenance and of adequate conditions; and (3) existence of negative impacts of irrigated agriculture, for example, to the environment.

Gomes and Vergolino (1995) observe that more than 50 percent of the total investments in the Northeast is done by the public sector, which demonstrates the leading role of official agencies in promoting economic growth in the region. But even if the formal justification for official water resources intervention is to serve the poorer groups of society, these have been very marginally and unsatisfactory assisted at the implementation of water development policies in SFRB. Most of the landless groups in the region are families of former squatters or sharecroppers who have lost their posts in dam constructions or with irrigation schemes (i.e., because the number of settled irrigators are normally smaller than the number of people who were previously displaced). Yet the way irrigation has been implemented in public districts is inefficient and expensive. Shortages of reliable data and mistakes during the planning process have led to technical distortions and waste of resources. This has not, however, curtailed the schedule of new irrigation projects. The situation ends up in perverse and successively failed efforts, since a higher priority is given to the implementation of new irrigation plans instead of improving the operation and management of existent water schemes. While utilizing almost all governmental funds allocated for the region, irrigation has not been sufficient to create jobs or to raise standards of living of the majority of the people (Collins, 1991). The process of selection of new farmers for irrigated districts does not accommodate those sectors of the rural population who are vulnerable to abnormally dry periods, because only a small proportion of the selected public had ever been badly affected by droughts. That creates, then, competition for water and financial resources between commercial crops (such as tropical exportable fruits) and staple food production.

Baer (1995) notes that public employment and investments have done little to increase productivity and have only increased dependency on transfers from the rest of the country, especially from federal rescue during drought years. Calvert and Reader (1998) criticize the "big-is-beautiful" approach used in the drought relief schemes in SFRB, because the results are seen as environmental damage, social impacts, concentration of land-holding in large farms, and corruption. Calvert and Reader (1998) make reference to a confidential study of the World Bank showing that only US$40 of every US$1,000 going as aid actually reaches the drought victims themselves. Souza (1994) claims what seems to be a fundamental conclusion about the water development that has taken place in SFRB: the social benefits of irrigation would be much more significant if there was a more equitable social structure in the region.

Unsolved Water Conflicts

The fourth major problem of the water development in SFRB is related to open conflicts for water allocation, especially between hydroelectricity and upstream irrigation. Both activities involve large volumes of water and are particularly concentrated in the Sub-Middle of the basin. In the next decades, there are foreseeable tendencies to improve the consumptive uses of water, especially pushed by irrigation. Vieira (1998) projects future scenarios for the year 2020 when the total water demand of SFRB is expected to increase 47 pecent in comparison to 1991. The projection identifies only marginal alteration

in water availability in the same period. The author describes few Water Sustainability Indicators for the water management of SFRB. For example, the ratio between water demand and availability is presently 0.15, but it would be 0.21 in the year 2020. Another indicator is the ratio between demand and potentiality of water use, which is presently 0.23 and would be 0.34 in 2020.

In addition to the very vacillating process of planning and integration of SFRB, there have been only sector demands, such as irrigation, hydroelectricity, urban consumption or navigation, that have been involved in continuous and unsolved conflicts. However, there are not only legal or economic causes for those disputes, but also historical and social causes of the same question that must be considered. Efficient water management comes together with structural sociopolitical transformations, giving room to a reliable and proactive process of water negotiation. That implies reorientation of political and economic priorities, especially to accommodate conflicts and to assist the majority of the population, who has been maintained apart from the benefits of the attempted water development. Massive government investments in water resources development (more than US$12 billion since 1948) have not resulted in greater economic and political autonomy of SFRB. On the contrary, the most interested parties have been lobby groups and engineering construction companies. Some positive improvements on social indicators have been too locally circumscribed around the sites of irrigated production (Khan and Campos, 1995). The following is a summary of the principal conflicts between water users in SFRB.

Irrigation vs. Hydropower

With the construction of major hydropower plants (Table 4), the Sub-Middle became the main supplier of energy to the Northeast region. It was done in parallel with the expansion of irrigated production in the last five decades. The total nominal figure of water diverted by irrigation represents 22 percent of the mean annual river flow or 35 percent of the regularized flow (ARIDAS, 1995). Consequently, the most severe water conflict in SFRB is found between upstream irrigation and hydroelectric generation. Andrade Filho (1986) points out that the risk of affecting power generation is very high and the occurrence of concrete deficit situations depends upon the increase of the irrigation use.

Irrigation, as an economic use of natural resources, is only possible in very particular sites of SFRB. This tends to reinforce conflicts around those privileged areas and reduces the ability of irrigation to stimulate development in most of the municipalities along the basin. Locally, in many São Francisco tributaries, scarcity of water is already a serious constraint. In 1996, for example, in the Fêmeas River (west of Bahia) one hydropower plant had 107 days of restricted operation due to upstream irrigation consumption (Genz and Cardoso, 1998). Similar examples are found in the tributary rivers Verde Grande, Verde Pequeno, Ipanema, and Salitre, among others, where agricultural depletion of water has temporarily dried up or drastically reduced the river flow of those watercourses.

Flood Control and Navigation vs. Hydropower

Flooding is a regular threat in SFRB that mainly affects the population living in low-lying areas. Even so, flood control is not one of the main purposes of dams along the river. In order to reduce potential flood intensity, it is necessary to reduce water storage in the dams from December to March (e.g., the Sobradinho Dam should restrict its volume to 71 percent) leaving a "reserve volume" to receive one potential excess amount of water (DNAEE, 1983). This operation can affect the efficiency of hydroelectricity production and raise the risk of blackouts. Analogous procedures, as well as complementary constructions, are required to facilitate fluvial transportation, representing another source of conflicts.

In the last few decades, navigation along the SFRB has diminished its importance, due to road constructions. The present fleet is formed of old ships with more than 30 years of use, transporting only 150,000 tons per annum, while there is demand for two million tons. Apart from engineering interventions and infrastructure investments, navigation improvement would also require a higher stabilized water flow, or more water.

Table 4. Main Hydroelectric Power Plants in the Sub-Middle of SFRB

Power Plants	*Electric Power (MW)*	*Reservoir Capacity (km^3)*	*Inundated Surface (km^2)*	*Observations*
Paulo Afonso (I,II,III & IV)	3,984	-	-	Paulo Afonso I - 1955 Paulo Afonso II - 1961 Paulo Afonso II - 1971 Paulo Afonso IV - 1979
Moxoto	440	1.20	100	Renamed Apolonio Sales; construction began in 1971; expansion in 1979
Sobradinho	1,050	34.10	4,214	Concluded in 1978; 75,000 persons were displaced during the construction
Itaparica	1,500	10.78	834	Renamed Luiz Gonzaga; finished in 1988; 50,000 persons were displaced
Xingo	3,000	-	-	Inaugurated in 1994 (first part); prevision for more than 2,000 MW

Source: PLANVASF (1989).

CHESF Privatization vs. Its Public Administration

Hiding noble and ignoble motivations, the privatization of the federal hydroelectricity utility of the São Francisco (CHESF) is a burning matter of discord. The reason is that CHESF is in charge of 10,700 MW of hydroelectric power generation, being the biggest individual generator in Brazil (the total hydropower potential of SFRB is 26,336 MW, according to ELETROBRÁS, 1999). Even though, Simpson (1999) argues that CHESF has demonstrated lack of ability to continue the development of hydroelectric potential with a multi-purpose water framework. Its privatization, then, could somehow facilitate water management reforms, as long as the government first establishes clear regulations to the new private utility. However, local groups in the Sub-Middle (called by adversaries "the water owners") have pressed for the postponement of a public auction that was initially scheduled to March 30, 1999. These groups have traditionally benefited from governmental investments in the region and do not want any sort of change in the frame of established practices. On the other hand, CHESF privatization is an important chapter of the national sell-off program and receives great attention from opposing and supporting interested parties.

Even with public administrators, the policy of energy generation in SFRB has ignored the effects on the space where large populations live (Góis et al., 1992). In this regard, the construction of dams for hydroelectric generation has displaced more than 110,000 persons in the Sub-Middle. The great majority is formed by families of sharecroppers or squatters with no documented land. Therefore, they receive no compensation when displaced and are forced to migrate. The direct consequences are disruption of the economic organization of these areas and disintegration of traditional knowledge. According to our personal interviews in the area in the year 1999, displaced people complain that the main beneficiaries of hydropower dams are large-scale irrigators and cities demanding energy hundreds of kilometers from the river.

Interbasin Water Transfers

Since the beginning of the 20th Century, there has been a recurrent proposal to transfer water to river basins northwards of SFRB. The objective is to supply rivers with small or absent flow during dry seasons, providing water for irrigation and urban consumption. This ambitious project is called *Transposição* (interbasin transfer) and would require several billion dollars for river diversion, water pumping, and agriculture infrastructure. There are different designs for the later utilization of the conveyed water (Table 5), mainly reflecting antagonistic political pressures to satisfy local interests. In consequence, the implementation of such plan fundamentally depends on a necessary reorganization of national political forces, a kind of new "Colorado River Compact" (i.e., the one agreed in the Western United States in 1922 between Upper Basin and Lower Basin states).

As an outcome of the changes around the coalition which was supporting the federal government, a new interbasin proposal was put forward in the year 1999. The main goal of the new proposition is to reduce inefficiency in the operation of eight major dams and several irrigation systems in other watersheds northwards. In those receiving basins, the current water management efficiency is barely 25 percent, due to high evaporation and uncertainties of the climate. The proponents of the new project maintain that water transferred would produce an important synergistic effect with the simple guarantee of supply. The positive externalities would be reduction in

Table 5. Main Studies about Interbasin Transfers in SFRB

Proposer Institution	*Transferred Flow (m^3/s)*	*Remaining Flow (m^3/s)*	*Irrigation (ha)*	*Reduction in Energy or Power*	*Benefitted Population*
DNAEE (1983)	1,100	1,150 in. Paulo Afonso	2.3 million (50% in SFRB)	2.5 MW	3 million
HIDROSERVICE -PRC/DNOS (1986)	280	1,570	1.547 million (52% in SFRB)	227 GWh/year	(different scenarios)
SEPRE/MPO (1995)	180	-	120,000 in 5 years	-	6 million
CODEVASF (1996)	180 (including the addition of supplementary flow coming from upstream river basins)	-	1.6 million	-	30 million in 30 years
MI (1999)	64	2,000	223,000	1,208 GWh/year	7 million

Sources: Araujo and Ribeiro (1995); CODEVASF (1996; 1999); and MI (1999).

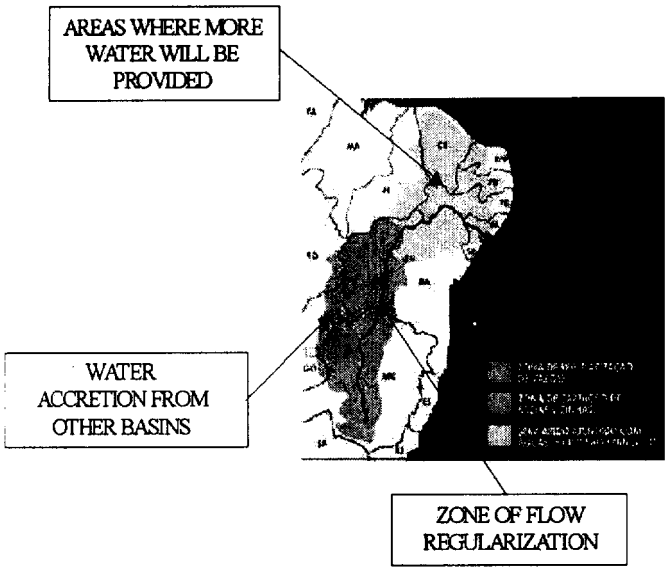

Figure 4. CODEVASF Project of Interbasin Transfer, which involves accretion of water in the upper SFRB (from other rivers in the center of Brazil) and transfer of water from the sub-middle (to other states northwards).

uncertainty, more rational use of resources and a higher grade of confidence in related official policies. This project devises two distribution systems taking water from the São Francisco River and conveying through the so-called "North and East Axis." The water will be pumped 160 meters uphill and it is expected to involve 240 km of tunnels and 2,400 km of distribution canals. Additional volumes of water are expected to be supplied from other rivers in the center of the country and diverted to SFRB (Figure 4). The estimated cost of this new project is around US$1.5 billion, only for interbasin transfer, which would represent a cost of US$0.07/m^3 to final water users. To implement it, the main loser will be the hydroelectricity utility (CHESF), due to reduction in water flow. Such losses would represent 12 MWh/h at the beginning of the interbasin operation in 2010, reaching 138 MWh/h in 2025 (i.e., 138 MWh/h represents two percent of the total power generation or US$40 million per year), all according to Cagnin (2000).

However, along the whole history of water development in SFRB, there has been plenty of evidence of major problems during the implementation of water projects, routinely resulting in corruption, inefficiency and prolongation of social tensions, as already discussed above. In spite of that, the situation is not different now with this proposal of interbasin transfer, which is again surrounded by enormous technical uncertainties and too many political pressures. The discussion around the construction details has not been done with enough transparency and convincing accountability of environmental, social and financial costs. It is either not clear who is going to bear the negative externalities of reducing the river flow and the impacts of manipulating water for hundreds of kilometers, altering local ecology and hydrology patterns. There are indeed several contradictions between the discourse of the federal Ministry in charge of the interbasin project and the foundations of the proposal itself. The way it is being designed it does not intended to ameliorate the social reality or revert the impacts on the environment. It has no integrated approach to the water problems of SFRB and the other involved river basins. In addition, it does not provide incentives to public participation in order to deal with the foreseeable externalities (i.e., according to the consultancy in charge of the EIA, this new interbasin project would create 38 negative and just 11 positive impacts). Overall, it is a single engineering plan, neglecting the sum of problems of the entire river basin.

As will be discussed, there are other local, certainly more sustainable, options to be considered before implementing such mammoth project. It is not reasonable to talk about interbasin investments without a complementary policy of agrarian reform. That means for SFRB not only land distribution, but also incentives to production, clear property rights, good rule of the law and, especially, an effective policy of water security. For instance, Smith (2000) points out that the interbasin transfer project strongly needs a systematic treatment between the donor and beneficiary basins, since the situation of water scarcity is not an isolated process, but is much more a product of unbalanced social relations. Without such social and geopolitical preconditions, the project will only benefit small portions of land and few cities along the water distribution network, what would aggravate water conflicts, waste of resources and environmental problems.

Enhancing Water Management Guidelines to Improve the Water Management Framework of SFRB

As a general rule, very little can be accomplished in environmental management in Brazil without transformation in the relations between State, society and the classical mechanism of representative democracy (Krause, 1997). Another crucial observation is that water management in SFRB cannot be dissociated from broader economic and political processes, being the success of the management highly dependent on information disclosure and responsibility share. Furthermore, to address the requirements of sustainable water management raised in our initial definition, two critical aspects are fundamental: integrated efforts and environmental stewardship. In order to fulfill all these requisites, the five critical reforms necessary to strengthen the water management of SFRB are discussed..

Reorientation of Government Procedures and Priorities

The water problems of the semi-arid SFRB are strikingly embedded in the legacy of large structural plans and

major water constructions. There is little coordination of efforts and scarce long-term achievements. Such an approach is mainly a translation of the traditional orientation public agencies have followed throughout history. The complex Brazilian political system often makes reform difficult and hegemonic forces are neither prepared nor interested in achieving more judicious water management, which is needed. Official water interventions would achieve better results in moving from prioritizing large dams and other heavy engineering constructions to focus on smaller local water systems and associated non-structural measures. Beekman (1998) points out that the era of large water schemes is ending and that new assessments of efficiency must consider hard realities, such as environmental and social consequences, and the fact that construction costs are increasing in real terms. Clarke (1991) timely states that the real problem of water management is a form of "water blindness" that prevents people from seeing how real the water problems are. The author warns that developing countries do not ask the same question as the Western societies (how much water do we need?), but the best they are able to ask is: how much water is there and how can we best benefit from it?

Likewise, more socially committed governmental policies would address reduction in drought vulnerability, facilitate access to land and water (e.g., through market forces that favor reduction in land tenure concentration), and promote better standards of water consumption. Particularly, considering the high probability of recurrent drought periods, the focus needs to be placed on risk management instead of emergency measures. Part of that has to do with higher level of public preparedness to overcome dry spells and also a strategic distribution of responsibilities among involved parties (government and society), taking into account the necessary adaptation, coordination and complementation of available tools. The existing network of climatology and weather observation needs to be enhanced, with improvements in technology, personnel and equipment. Another sector that requires considerable reorientation in its purposes is the program of irrigation expansion. The reason is that irrigation technology played an important role in achieving food security during the time of the "Green Revolution," but now must play the same role in providing water security for the poor (Barker and van Koppen, 1999).

Implementation of Water Management Instruments

Visscher et al. (1999) observe that there is now a general acceptance of the opportunity for integrated water management, as well as a growing awareness that water is a limited resource, but movement from the enshrining of principles to practical application strategies still remains poor in developing countries. In this regard, efforts involving the adoption of instruments of water management are basic requirements to improve the efficiency of water consumption and conservation. In the individual case of SFRB, the process of implementing new water instrument has had a slow departure. That alone demonstrates serious weaknesses of the existing institutions to implemen the aforementioned new national legislation. For instanc very few tributary committees were installed to date an there is still not a central committee overseeing the whol catchment. The emission of water permits (to abstractio or pollution emission) is also incidental and fragmente moreover the allocation of water permits in a context o significant land accumulation, such as in SFRB, is a non trivial process, since many irrigators and water users ar not documented landowners. Water fees and taxes ar still dependent on the creation of mechanisms of regula tion and control (see next item). Overall, on par with othe broader transformations of the water sector in SFRB, it i fundamental to consolidate the institutional framewor of management in order to support the gradual adoptio of those water management instruments.

Market and Non-market Incentives to Water Management

The balance between efficiency and equity must be priority in the water management process of SFRB due t the social relevance water plays in the human activities o the river basin. There are various forms of economic in centives that, when wisely adopted, can lead to achieve ments in water conservation and water quality, at lowe transaction costs and benefiting the majority of the popu lation. For instance, tariffs on pollution emission and o water consumption are robust tools of environmental man agement, as already demonstrated in positive recent ex periences in other river basins in Brazil (in the state o Ceará, for water tariffs) or in South America (in Colom bia, for pollution emission tariffs). Nevertheless, the suc cess of the introduction of economic instruments particularly involving charges for water use or effluen emission, is highly dependent on a delicate negotiation pro cess, since in SFRB farmers do not have to make a direc payment for water usage as yet (i.e., there are the norma payments for electricity, which somehow represent an in direct stimulus to save water). In the cities there is n general adoption of water metering, and water tariffs ar politically controlled, and normally subsidized. Only in dis tricts of irrigation there are payments for watering ser vices, but water tariffs are calculated taking into accoun external reasons, rather than as functions of the real cost of pumping and distribution.

To deal with the major deficits of supply and sanita tion in SFRB, there are innovative strategies to boost de centralized, small-scale constructions. Coping with th high demand for water investments and the slow pace o official responses, there are successful examples of non conventional fund raising schemes in similar marginalize socioeconomic areas around the world (Aureli, 1999). I those regions, so-called "microcredit to water" program have helped poor people living in rural and peri-urban ar

eas not only for building facilities, but also for sustaining the buildings with adequate provision for operation, proper utilization, and maintenance of the systems.

Water Husbandry and Technology Procurement

The water uses in SFRB have generally suffered from inadequate techniques of water manipulation in urban and rural areas, with the dominant local practices still too much grounded on supply-driven policies. New approaches should involve innovative technologies, based on ecological and conservative procedures, as well as using performance assessment to water management. There are encouraging possibilities of technology leapfrog, especially exchanging know-how with other semi-arid regions of developing countries. At the SFRB level itself, various alternative practices aimed at providing more efficient water usage in rural areas have been developed. Despite the positive outcomes, it has not always received appropriate consideration from policy-makers. Few research centers, like EMBRAPA (the National Agriculture Corporation), have invested in better-adapted technologies, even with chronic financial and institutional constraints. For example, Gischler and Jáuregui (1984) discuss pioneer research carried out in SFRB relating to low-cost methods of small-scale irrigation, rainwater harvesting techniques, and underground dams. Also Netto et al. (1992) identifies strategic micro-climatic areas with considerable more moisture available (e.g., mountains, valleys, sites with favorable geomorphology, etc.) where rainfed agriculture can be more successful. The development of plant varieties that are less water-intensive and adapted to high salinity levels helps to deal with food scarcity and minimize harvest risks. For the case of SFRB, small-scale irrigation has clear technical and social advantages over larger schemes, particularly when small farmers have a major controlling influence and use a level of technology that they can effectively operate and maintain. Localized irrigation (drip and micro-sprinkler systems) represent considerable gains in water and energy savings even with the high level of investment and technology involved. Partial irrigation (or supplementary irrigation, or yet "deficit irrigation") turns to be an important option in dealing with increasing water competition. Also up to 60 percent of urban wastewater can be treated and reused by agriculture in semi-arid zones (Klohn and Appelgren, 1999).

With a situation of extremely high evaporation taking place in reservoir surfaces, soil water assumes a very strategic contribution to accumulate water during long dry periods, since groundwater has the great advantage of being protected against evaporation losses. In order to foster efficiency, it is necessary to consider both underground and surface water as a common interchangeable system. Initiatives to provide water security in remote areas of SFRB, especially during drought periods, have significant social relevance, because those areas that suffer from diseconomies of scale cannot attract new water investments. Groundwater plays a vital role in the water supply for domestic and rural needs, particularly with the development of low-cost desalination techniques adapted to developing semi-arid regions. Better access to water would allow people to remain there with acceptable standards of living and would produce better allocation of economic resources. Particularly in the countryside, local water constructions are strategic in helping small farmers and involving rural communities. Salati et al. (1999) states that the storage of rain water is another effective alternative to public supply, especially to diffuse consumption in rural areas of the backland Northeast.

Overall, there is not a simple practice that is able to solve the water scarcity problem, but it requires a range of integrated and coordinated efforts in terms of water husbandry and sound techniques that could be summarized as: (1) improved and more rational use of existing water sources; (2) priority given to small irrigation, especially when practiced in collective forms of association; (3) more adapted technologies of rainfed agriculture; (4) appropriate techniques of cultivation of the humid riverbank soils and other "moisture-strategic" sites and microclimates; (5) well-defined emergency plans for shorter and longer dry periods; (6) strength and expansion of agroindustry and cooperatives; (7) good databank on water resources; (8) continuous monitoring; and (9) capacity building.

Public Participation

In SFRB, it has rarely been a political practice to involve people in the decision-making process. The present situation is one of profound public marginality, leaving particular communities along the riverbanks and in small cities totally unable to deal with the river problems. In the rare moments when stakeholders can take part in the debate, it is much more at an information level than exactly at the decision-making level. As a result, it is not easy to transform the existing paternalistic tradition when the population is so habituated to it. Magalhães (1994) notes that it is crucial to build societal engagement in that region, but it is "difficult to persuade societies suffering from poverty and starvation to consider the long term." The reality of illiteracy and populism is the result, but also serves to perpetuate poverty. Additionally, financial and political discontinuity during the implementation of official programs has instigated public disappointment and a consequent lack of support. Tapia (1999) states that water management in semi-arid regions must be even more integrated than in other parts of the globe and that stakeholder participation is a key feature of the process. Stakeholder participation does not mean just public consultation or legitimization of previous decisions. Decentralization is translated into effective gains when people are involved from the very beginning of the planing process, taking share in the decisions about priorities of water development programs, budgetary allocation, and project evaluation. Measures should be

supported upon integrative community efforts, starting from a clear and precise determination of real and feasible objectives and evolving in a participatory manner throughout the water plans and initiatives.

Decision-making with effective public participation is fundamental not only to raise water conservation awareness, but also to commit policy-makers to the sustainable and decentralized management of water resources. The examples of ongoing hydropower, irrigation, and interbasin transfer projects make clear the insufficiency of present solutions to assure benefits to the whole collectivity of SFRB. Policies and legislation on conflict mediation should address the local reality of income disparity, because if the water management in the SFRB was to seek sustainability, solutions should be viewed based on the larger social and institutional picture. Political will is essential to produce a real change in water management practices, since it would never be implemented without broad-based political endorsement.

The empowerment of the less privileged sectors of the society addresses complex and dialectic issues. Water resources participatory management can contribute to

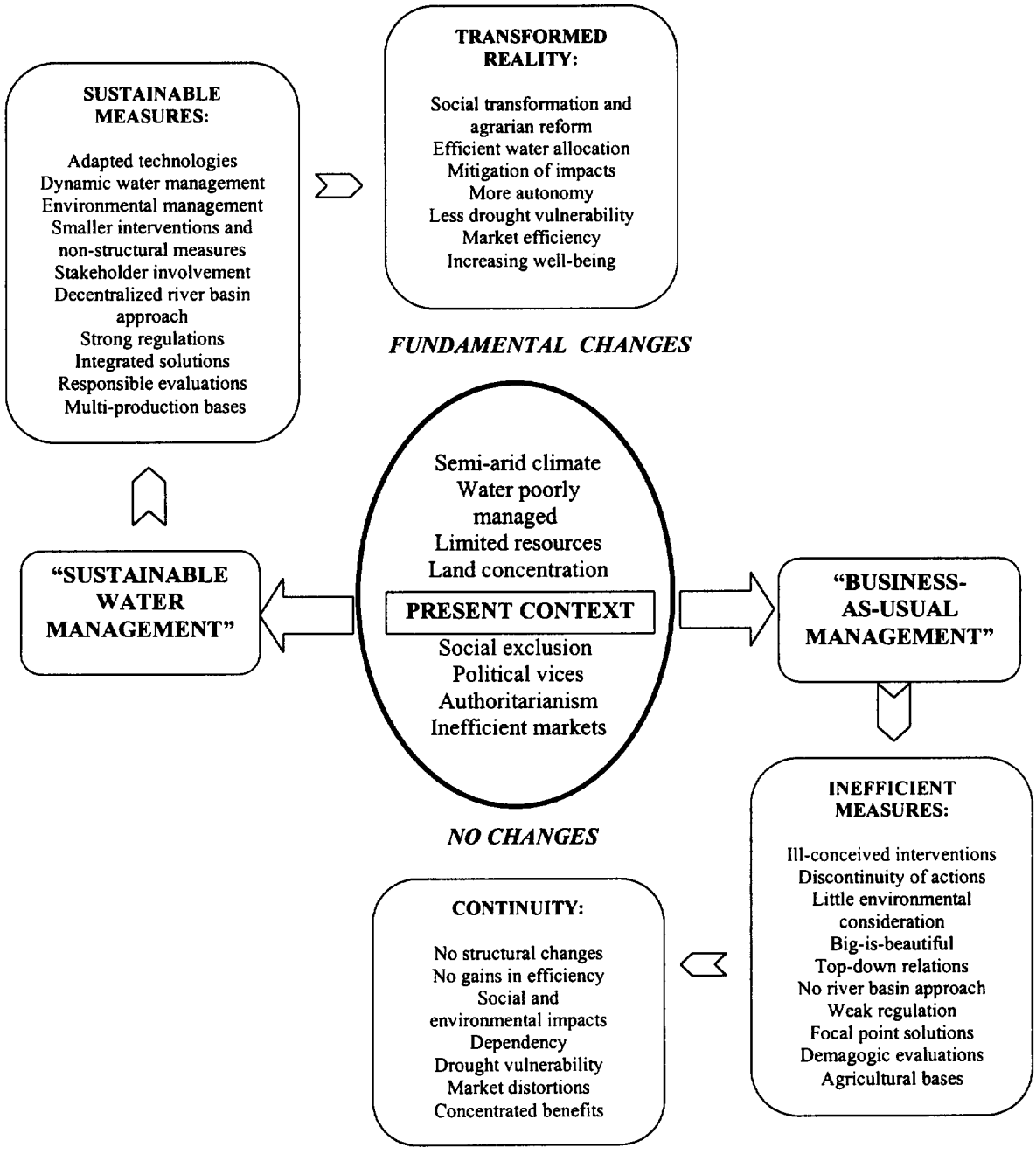

Diagram 1. Constrasting opportunities for water management in the sub-middle São Francisco River Basin

broaden the democratic game by creating new arenas of representation and demand articulation. First and foremost, water resources management in SFRB depends of an ample consensus towards the opportunity of Sustainable Development. In having such a basic agreement, it is possible to evolve to projects and actions without repeating the same mistakes of the past: point solutions, inefficiency, discontinuity, corruption, pork-barrel programs, limited access to water supply, and environmental degradation. Diagram 1 summarizes, the contrasting alternatives for water management in the Sub-Middle São Francisco River Basin, which are the conservative, fragmented ("business as usual"), and the diligent, integrative ("sustainable water resources management") approaches.

Conclusions

Taking into account the analysis of the water problems of the Sub-Middle SFRB discussed in the previous pages, it is possible to suggest a few conclusions and raise few basic recommendations:

- The water question of the Sub-Middle SFRB is emblematic of the water management problems in the semi-arid backland of the Northeast region. There are chronic difficulties in connecting water planning to water management in SFRB, which have resulted in discontinuity and waste of resources. Instead of trying to solve the problems on existing irrigation and hydropower projects, policy-makers prefer to promote new construction and introduce new water programs. In addition, there are very few evaluations of past expenditures, and little allocation of blame for past mistakes and distortions.
- Adverse drought periods in the semi-arid SFRB involve climatic and geographic features, but the human circumstances are also strongly determined by historical and political legacies. Effective solutions to water allocation distortions in SFRB depend primarily on transformations relating to established political asymmetry. Tradition has resulted in a conservative oligarchy dominating public water services in the region, which in turn has perpetuated authoritarian and demagogic practices. However, if the State does not move towards a better representation of the majority of the society, the opportunities to improve water management will not result into real gains.
- Water management in SFRB requires a new, comprehensive approach, which provides a more manageable framework to consider together natural and artificial resources. Two main issues need attention: integration and environmental stewardship. Recent formulated instruments of water management must be put into practice, such as river basin organization, emission of water-permits, and charges for bulk water, when it is socially and economically acceptable. Favorable opportunities for better adapted technologies, in terms of water allocation, water consumption, and drought mitigation, are proven available. Small-scale irrigation and local water constructions appear to be preferable strategies in reducing drought vulnerability and environmental impacts, and produce gains in sustainability. At the same time, large engineering interventions require more transparent impact assessment and proper mitigation measures.
- For the complex experience of SFRB, the major challenge is to act simply without being minimalist or reductionist in overcoming the existing tradition of paternalism and centralization. If sustainability becomes too idealistic or even impossible to conciliate with the process of development, maybe it is better to talk about a sort of "semi-sustainability," where "the best possible approach is taken by balancing human needs and human rights against the side effects resulting from the necessary manipulations with landscape components" (Falkenmark, 1997b). More sustainability is only achieved by dynamic and heuristic procedures, clear rules, democratic and decentralized institutions.
- Sustainable water management in SFRB requires nonlinear solutions and addresses a different mode of economic development. Water is a structural factor in the SFRB society, where water control is a part of and a translation of sociopolitical power. There is correspondence between effective water management and social transformations, such as decentralized decision-making, law enforcement, improved formal education, and deeper environmental concerns.
- As a whole, water management in the São Francisco River Basin remains part of wider and complex social challenges.

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References

Andrade Filho, M.G. 1986. *Modelo de Otimização para o uso Múltiplo da Água do Rio São Francisco.* M.Sc. dissertation. Campinas: UNICAMP.

Araújo, J.T. and M.B.D. Ribeiro. 1995. *Apreciação Crítica sobre o Documento "Projeto de Transposição do Rio São Francisco."* Salvador: Instituto Miguel Calmon.

ARIDAS Project. 1995. *Nordeste: Uma Estratégia de Desenvolvimento Sustentável.* Brasilia: Projeto Áridas.

Aureli, A. 1999. "Microcredit and Water." *Afers Internacionals* 45–46: 169–178.

Baer, W. 1995. *The Brazilian Economy: Growth and Development.* 4th edition. London, United Kingdom: Praeger.

Barker, R. and B. van Koppen. 1999. *Water Scarcity and Poverty.* IWMI Water Brief No. 3. Colombo: International Water Management Institute.

Beekman, G.B. 1998. "Water Conservation, Recycling and Reuse." *International Journal of Water Resources Development* 14: 353–364.

Cagnin, J.U. 2000. Engineer in charge of the São Francisco Interbasin Transfer Project, Ministry of National Integration, Brasília, *personal communication.*

Calvert, P. and M. Reader. 1998. "Water Resource Management in Brazil." In *Water Resource Management: A Comparative Perspective.* D.K. Vajpeyi, ed. London, United Kingdom: D.K. Praeger.

Clarke, R. 1991. *Water: The International Crisis.* London: Earthscan.

CODEVASF (Company for the Development of the São Francisco Valley). 1989. Plano Diretor para o Desenvolvimento da Bacia do São Francisco. Relatório *Final.* Brasília: CODEVASF, SUDENE and OEA.

CODEVASF (Company for the Development of the São Francisco Valley). 1996. Plan for Sustainable Development of the São Francisco River Basin and the Semi-Arid Northeast. Brasilia: CODEVASF.

CODEVASF (Company for the Development of the São Francisco Valley). 1999. *O Vale do São Francisco.* http://www.codevasf.gov.br/frame_v.html.

Collins, J.L. 1991. "Production Relations in Irrigated Agriculture - Fruits and Vegetables in the São Francisco Valley (Pernambuco/Bahia), Brazil." *IDA Working Paper No. 80.* Binghamton: Institute for Development Anthropology.

DNAEE (National Department of Water and Electrical Energy). 1983. *Diagnóstico da* Utilização dos Recursos Hídricos d Bacia do Rio São Francisco: Relatório *Síntese.* Brasili DNAEE.

Dourojeanni, A. 1994. *Políticas Publicas para el Desarroll Sustentable: La Gestión Integrada de Cuencas.* Santiag ECLAC.

ELETROBRÁS (Brazilian Electrical Corporation). 1999. *Potenci Hidroelétrico Brasileiro-1998.* http://www.eletrobras. gov.br

Falkenmark, M. 1997a. "Meeting Water Requirements of an Ex panding World Population." *Philosophical Transactions the Royal Society of London,* Series B, 352: 929–936.

Falkenmark, M. 1997b. "Society's Interaction with the Wate Cycle: A Conceptual Framework for a More Holistic Ap proach." *Hydrological Sciences Journal* 42: 451–466.

Furtado, C. 1984. O Nordeste: Reflexões Sobre uma Polític Alternativa de Desenvolvimento. *Revista de Economi Política* 4: 5–14.

Gasques, J.G., C.H.M. Coelho, M.B. Almeida, F.A. Soares, L.A. Silva, M.J. Nogueira, R.C. Lins, and J.G.B. Oliveira. 199 Nordeste do Brasil: Diagnóstico, Cenários e Projeções pa os Anos 2000 e 2020. In *Desenvolvimento Sustentável n Nordeste.* G.M. Gomes, H.R. Souza and A.R. Magalhães, ed Brasilia: IPEA.

Genz, F. and E.R. Cardoso. 1998. "Conflito de Uso da Água Caso do Rio das Fêmeas - Oeste da Bahia." In *Proceeding of the Simpósio Internacional Sobre Gestão de Recurso Hídricos, Gramado, Brazil.*

Gischler, C. and C.F. Jáuregui. 1984. "Low Cost Techniques fo Water Conservation and Management in Latin America." *Na ture and Resources* 20: 11–18.

Góis, J.A., M.F.A. Paiva, and S.M.G. Tavares. 1992. "Projetos d Irrigação no Vale do Baixo São Francisco." *Texto pa Discussão No. 268.* Brasilia: IPEA.

Gomes, G.M. and J.R. Vergolino. 1995. A Macroeconomia d Desenvolvimento Nordestino. *Texto para Discussão No.* 37 Brasília: IPEA.

Hall, A.L. 1978. *Drought and Irrigation in Northeast Brazil* Cambridge, Massachusetts, USA: Cambridge Universit Press.

IBGE (Brazilian Institute of Geography and Statistics). 199 *Censo Demográfico 1991.* http://www.ibge.gov.br.

Kelman, J. 1997. "Building a Water Resources Management Sys tem in Brazil - A Status Report." In *Sustaining our Water into the 21st Century.* J. Lundqvist and P. Gleick, ed Stockholm, Sweden: Stockholm Environmental Institute.

Kettelhut, J.T.S., L. Amore, L. and J.M. Leeuwestein. 1998. "A Experiência Brasileira de Implementação de Comitês de Bacia Hidrográficas." In *Proceedings of the Simpósi Internacional Sobre Gestão de Recursos Hídricos Gramado, Brazil.*

Khan, A.S. and R.T. Campos. 1995. "Efeitos das Secas no Seto Agrícola do Nordeste." In *Desenvolvimento Sustentável n Nordeste.* G.M. Gomes, H.R. Souza, and A.R. Magalhães eds. Brasilia: IPEA.

Klohn, W. and B. Appelgren, 1999. "Agua y Agricultura." *Afer Internacionals* 45–46: 105–126.

Krause, Sustent *Sustent* São Pau

Livingston nomics Drough *nomics*

Lélé, S. 19 *tives, C* and Ind Natural of Man

Magalhães Semi-A 279.

MI (Minis *cisco.* sf.htm.

MI (Mini *Revital Rio São*

Netto, A.V Exceçã Brasil.' *Impact ment in*

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Redwood, *ronmer* ton, DC

Romano, ter Res cisco R *Basins* N.V. C United

Saito, I. an in the S *Latin A vironm* Nation

Krause, G. 1997. "A Natureza Revolucionária da Sustentabilidade." In *Meio Ambiente, Desenvolvimento Sustentável e Políticas Públicas*. C. Cavalcanti, ed. Cortez: São Paulo and Fundação Joaquim Nabuco: Recife.

Livingstone, I. and L.M. Assunção. 1993. "Engineering vs. Economics in Water Development: Dam Construction and Drought in Northeast Brazil." *Journal of Agricultural Economics* 44: 82–98.

Lélé, S. 1999. *Sustainable Use of Biomass Resources: Objectives, Criteria and Recipes*. Training Workshop on Criteria and Indicators of Sustainability in Rural Development: A Natural Resource Perspective. Ahmedabad: Indian Institute of Management.

Magalhães, A.R. 1994. "Sustainable Development Planning and Semi-Arid Regions." *Global Environmental Change* 4: 275–279.

MI (Ministry of National Integration). 1999. *Projeto São Francisco*. http://www.integracao.gov.br/programas/projto_sf.htm.

MI (Ministry of National Integration). 2000. *Plano de Revitalização Hidro-Ambiental da Bacia Hidrográfica do Rio São Francisco*. Brasilia: MIN, INPE and FUNCATE.

Netto, A.V.M., R.C. Lins, and S.F.S. Coutinho. 1992. "Áreas de Exceção Úmidas e Subúmidas do Semi-Árido do Nordeste do Brasil." In *Proceedings of the International Conference on Impacts of Climatic Variations and Sustainable Development in Semi-Arid Regions, Fortaleza, Brazil*.

PLANVASF (Master Plan for the Development of the São Francisco Valley). 1989. *Programa Setorial de Energia*. Brasilia: PLANVASF.

Ponce, V.M. 1995. "Management of Droughts and Floods in the Semiarid Brazilian Northeast - The Case for Conservation." *Journal of Soil and Water Conservation* 50: 422–431.

Redwood, J., III. 1993. *The World Bank Approaches to the Environment in Brazil: A Review of Selected Projects*. Washington, DC, USA: World Bank.

Romano, P.A. and E.A. Cadavid Garcia. 1999. "Policies for Water Resources Planning and Management of the São Francisco River Basin." In *Management of Latin American River Basins: Amazon, Plata and São Francisco*. A.K. Biswas, N.V. Cordeiro, B.P.F. Braga and C. Tortajada, eds. New York: United Nations University Press.

Saito, I. and N. Yagasaki. 1995. "Drought, Irrigation, and Changes in the Sertão of North-East Brazil." In *The Fragile Tropics of Latin America: Sustainable Management of Changing Environments*. T. Nishizawa and J.I. Uitto, eds. New York: United Nations University Press.

Salati, E., H.M. Lemos, and E. Salati. 1999. Água e o Desenvolvimento Sustentável. In *Águas Doces no Brasil: Capital Ecológico, Uso e Conservação*. A.C. Rebouças, B.P.F. Braga and J.G. Tundisi, eds. São Paulo: Escrituras Editora.

Santos, D.G. 1999. Coordinator of River Basin Master Plans, Secretariat of Water Resources, Brasília, *personal communication*.

Sen, A. 1984. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford: Oxford University Press.

Simpson, L.D. 1998. The Brazilian Northeast Region and the Rio São Francisco. *International Journal of Water Resources Development* 14: 399–404.

Simpson, L.D. 1999. "The Rio São Francisco: Lifeline of the Northeast." In *Management of Latin American River Basins: Amazon, Plata and São Francisco*. A.K. Biswas, N.V. Cordeiro, B.P.F. Braga, and C. Tortajada, eds. New York, new York, USA: United Nations University Press.

Skidmore, T.E. 1999. *Brazil: Five Centuries of Change*. Oxford: Oxford University Press.

Smith, R. 2000. Cuidados com a Transposição. *Revista Economia e Mais* 40: 4–8.

Souza, H.R. 1994. "Agricultura Irrigada no Semi-Árido Nordestino." In *Desenvolvimento Sustentável no Nordeste*. G.M. Gomes, H.R. Souza, and A.R. Magalhães, eds. Brasilia: IPEA.

Tapia, R.P. 1999. "Análisis de la Gestión del Agua en Zonas Áridas y Semiáridas: Una Propuesta de Actuación." *Afers Internacionals* 45–46: 11–33.

Tendler, J. 1993. *New Lessons from Old Projects: The Workings of Rural Development in Northeast Brazil*. Washington, DC, USA: World Bank.

Turral, H. 1998. *Hydro Logic? Reform in Water Resources Management in* Developed Countries with Major Agricultural Water Use: Lessons for *Developing Nations*. London: Overseas Development Institute.

Vieira, V.P.P.B. 1998. "Water Resources in Brazil and the Sustainable Development of the Semi-Arid Northeast." *International Journal of Water Resources Development* 14: 183–198.

Visscher, J.T., P. Bury, T. Gould, and P. Moriarty. 1999. "Integrated Water Resources Management in Water and Sanitation Projects: Lessons from Projects in Africa, Asia and Latin America." *Occasional Paper Series No. 31*. Delft: IRC International Water and Sanitation Centre.

Wythe, G. 1949. *Brazil: An Expanding Economy*. New York, New York, USA: Twentieth Century Fund.