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Sustainable Use of Groundwater in the Semi-arid Ribbon Valleys of Northeast Brazil

Interim Knowledge Review

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List of Acronyms

AMAS	Associação Menonita de Ação Social	Mennonite Social Action
ASA	Articulação do Semi-Árido	Semi-Arid Articulation
AS-PTA	Associação Projeto Tecnologia Alternativa	Alternative Technology Association
CAATINGA	ONG Ambientalista (Ouricuri- PE)	Environmental NGO located in Ouricuri - Pernambuco
CARITAS	ONG Católica internacional	International Catholic NGO
CEDAPP	Centro de Apoio ao Pequeno Produtor (ONG de Pesqueira)	Support Centre for the Small Farmer (Pesqueira NGO)
CIDA	Agência Canadense de Desenvolvimento Internacional	Canadian International Development Agency
COMPESA		State Water Supply Company
CPR		Common Poor Resources
CPRH	Companhia Pernambucana de Meio Ambiente	Pernambuco Environmental Company
CPT	Comissão Pastoral da Terra	Pastoral Land Commission of the Catholic Church (Land Reform Movement)
DFID	Departamento de Desenvolvimento Internacional (do Reino Unido)	Department for International Development, UK
DIACONIA	ONG Evangélica	Evangelical NGO
EMBRAPA	Empresa Brasileira de Pesquisas Agropecuárias	Brazilian Agency for Agricultural Research (Federal)
FADURPE	Fundação Apolônio Salles (UFRPE)	Foundation within UFRPE (research services)
FETAPE	Federação dos Trabalhadores da Agricultura de Pernambuco	Federation of Agricultural Workers in Pernambuco
FIDA	Fundo Internacional para o Desenvolvimento Agrario (das N Unidas)	IFAD - International Fund for Agricultural Development
FUNAI	Fundação Nacional do Indio	National Indian Foundation
FUNASA	Fundação Nacional de Saúde	National Health Foundation
FUNDAJ	Fundação Joaquim Nabuco	Joaquim Nabuco Foundation
FUNTEPE	Fundo de Terras do Estado de Pernambuco	Land Fund of the State of Pernambuco (State Government Land Reform Agency)
IBAMA	Instituto Brasileiro do Meio Ambiente	Brazilian Environmental Intitute
IBGE	Instituto Brasileiro de Geografia e Estatística	Brazilian Institute of Geography and Statistics
INCRA	Instituto Nacional de Colonização e Reforma Agrária	National Institute of Colinisation and Agrarian Reform
INPE	Instituto Nacional de Pesquisas Espaciais	National Institute of Spatial Research
IPA	Instituto de Pesquisas Agropecuárias (Estadual)	Agricultural Research Institute (Pernambuco)
MMTR-NE	Movimento de Mulheres Trabalhadoras Rurais do Nordeste	Northeastern Rural Workers Movement

MST	Movimento dos Sem Terra	Landless Movement
OXFAM (UKI)	ONG Britânica (Escritôrio nacional em Recife)	UK NGO (National office in Recife)
P1 MC	Programa um milhão de cisternas	A Million Cisterns Programme
PFL	Partido da Frente Liberal (Governo Municipal de Pesqueira)	Liberal Front Party (Pesqueira Municipal Government)
PROASNE	Proyeto das Águas Subterráneas do Nordeste	Underground Water Project for NE Brazil
Projeto Dom Helder Câmera	Projeto de Reforma Agraria e Desenvolvimento Rural - financiado pelo FIDA	Land Reform and Rural Development Project funded by IFAD and The Ministry of the Environment
Projeto Renascer	Projeto de Reforma Agrária do governo do Estado e Banco Mundial	Land Reform Project (State Government and the World Bank)
PT	Partido dos Trabalhadores (Governo Federal)	Workers Party (Federal Government)
SECTMA	Secretaria de Ciência, Tecnologia e Meio Ambiente	Secretary of Science, Technology and Environment (State Government)
STR	Sindicato dos Trabalhadores Rurais	Rural Workers' Union
UFPE	Universidade Federal de Pernambuco	Federal University of Pernambuco
UFRPE	Universidade Federal Rural de Pernambuco	Rural Federal University of Pernambuco
WRMP		Water Resources Management Policy

Glossary of Portuguese terms

assentamento	Legally established rural settlement where each family is allocated an area of land.
assentado	A legally recognised settler in an assentamento.
parceleiro	A settler who, although not legally recognised, occupies land which he or she may have purchased.
morador	A resident – in this case of an *assentamento* with no land entitlement.

1 Introduction

The knowledge review presented in this report is part of an ongoing process of collating knowledge related to topics that are of relevance to the KaR Project goal and purpose. A review of available literature was undertaken at the start-up period of the Project in November 2003. An overview of this review is given in a tabulated form in Appendix A.

The various chapters given in this report have been compiled by various team members with contributions also from Samy Hotimsky, who is undertaking a PhD study at the University of East Anglia. Style of writing and presentation are therefore varied and only limited effort has been put into editing of text provided by the various contributors.

The knowledge review is by no means complete. More work is required to document the findings of water resources studies and field experiments carried out in the Project region in a more cohesive manner. There is also an ongoing requirement to explore in more depth the experiences gained in other parts of Brazil and the wider world. Part of this further exploration will be possible through the PhD study undertaken by Samy Hotimsky. His research is closely linked to the KaR project and a proposal has been submitted to DFID to attach Mr Hotimsky to the Project team.

2 Literature Review

2.1 Initial Review

The initial literature review was undertaken in November 2003 during the start up of the Project. The review was largely targeted at obtaining an initial understanding of the social and technical issues relevant to the purpose of the Project. A summary of the review is given in Appendix A.

2.2 Progress towards Sustainable Agriculture

The University of Essex in the UK has recently completed an audit of progress towards sustainable agriculture in 52 developing countries and concluded that improvements in food production are occurring through one or more of four mechanisms:

- intensification of a single component of the farm system – such as home garden intensification with vegetables and trees, vegetables and rice bunds or a dairy cow;
- addition of a new productive element to the farm system, such as fish in a paddy rice or agro-forestry, which provides a boost to total farm food production and/or income but which does not necessarily affect cereal productivity;
- better use of natural capital to increase total farm production, especially water (by water harvesting and irrigation scheduling), and land (by reclamation of degraded land), thus leading to additional new dry land crops and/or increased supply of water for irrigated crops;
- improvements in per hectare yields of staples through the introduction of new regenerative elements into farm systems (e.g. legumes, integrated pest management), and/or locally appropriate crop varieties and animal breeds.

Thus a successful sustainable agriculture project may substantially improve domestic food consumption through home gardens or fish in rice fields, or better water management, without necessarily affecting the per hectare yields of cereals. Nevertheless the study presents reliable data on per hectare yields change for 89 projects. These illustrate that agro-ecological approaches have led to an average 93% increase in per hectare food production. The most successful projects have attained up to 500% increases.

However, food outcomes are not the only measures of success. A selection of the kinds of impact reported in these sustainable agriculture projects and initiatives include:

- improvements to natural capital, including increased water retention in the soils; improvements in water table (with more drinking water in the dry season); reduced soil erosion combined with improved organic matter in the soils, leading to better carbon sequestration; and increased agro-biodiversity;
- improvements to social capital, including more and stronger organizations at local level; new rules and norms for managing collective natural resources; and better connectedness to external policy institutions;
- improvements to human capital, including more local capacity to experiment and solve problems; reduced incidence of malaria in rice-fish zones; increased self esteem in formerly marginalized groups;
- increased status of women; better child health and nutrition, especially from more food in dry seasons; and reversed migration and more local employment.

There are four types of agro-ecological improvements that have played substantial roles in these food production increases:

- improvement to soil health;
- more efficient water use in both dry land and irrigated farming;
- pest and weed control with a minimum or zero pesticide use;
- whole system redesigns.

2.3 International Development Perspective

The international development perspective is best understood from the guidance and strategy documents issues by DFID. These documents provide information about the guiding principles related to sustainability and poverty alleviation, as these are currently perceived as being the most appropriate. The documents also provide an overview of the evolution of the guiding principles over the past decade or so. This evolution and the guiding principles, where of particular relevance to the Project, are summaries in the following:

The International Conference on Water and the Environment was held in Dublin in January 1992 as part of the preparations for the 1992 Earth Summit in Rio de Janeiro. The Dublin principles listed in the Dublin Statement of January 1992 indicate that:

1. *Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.*

2. *Water development and management should be based on a participatory approach, involving users, planners and policy makers.*

3. *Women play a central part in the provision, management and safeguarding of water.*

4. *Water has an economic value in al its competing uses and should be recognised as an economic good.*

The Dublin principles strongly underlie the purpose and objectives of the Project.

DFID's guidance manual on water supply and sanitation programmes describes sustainability, effectiveness, equity, efficiency and replicability as inter-linked concepts in the planning and design of projects. In the context of these concepts, DFID identifies the importance of including attention to social issues and having those built into the project programme. These issues relate to the various levels within the communities, from household to local-level institutions. DFID provides a 'Seven Step' approach towards successful partnership in water supply and sanitation between the professionals and officials on the one hand and the local communities on the other. Of particular relevance to a successful partnership is the willingness of the 'professionals' to take on board local knowledge, and involve the 'whole' community in the partnership process.

The DFID guidance manual proposes a sustainable rural livelihoods approach for arid and semi-arid areas, an approach which is responsive to people's own priorities for their livelihoods, and taking consideration of the fragility of the environment.

Water as an economic good implies a form af charging for the use of water. The common practice in many parts of the world is that water is a 'free-for-all' and that thus accountability is at a non-existent or very low level. Willingness to pay is clearly different from ability to pay and therefore abiding by the fourth Dublin principle is a challenge to sustainable water resource development.

2.4 Common-pool Resources Theory and Environmental Uncertainty

The term commons is used to refer to diferent types of resources and property institutions that involve some aspects of joint ownership or access (Dietz *et al.*, 2003). Common-pool resources (CPR) is a valued natural or human-made resource or facility that is available to more than one person and subject to degradation as a result of overuse (Dolsak and Ostrom, 2003). These resources usually exhibit two important caracteristics: non-excludability and subtractability. Non-excludability means that it is costly to exclude potential users of the resource both in terms of physical and institutional means, while subtractability means that one's person use subtracts what is available to others (Ostrom *et al*., 1999). Examples of common pool resources include fishing grounds, forests, the global atmosphere and groundwater (literally common pools).

Theory classifies common-pool resource problems into two broad types: appropriation and provision (Ostrom, 1997). Appropriation problems deal with the flow aspect of the common pool resource. It involves problems related to excluding potential beneficiaries and allocating subtractable flow. Providing the necessary level of inputs for positive yields is assumed to be given. On the other hand, provision problems are related to a resource stock, maintaining or improving its production capabilities and avoiding the destruction of the resource itself. As an example, farmers who jointly use an irrigation system must organize a variety of provision activities mostly due with maintenance. Provision activities might include deciding how many days a year will be devoted to routine maintenance, how emergency repairs will be handled, how work and financial burden will be allocated to individual farmers, and how new control gates and monitoring devices are to be installed (Ostrom ,1992). Appropriation activities are highly linked to these provision activities, since how much water is available at any given time is a function of maintenance performance (Ostrom and Gardner, 1993). Overcoming the public good aspects of establishing appropriate institutional supply for provision and appropriation activities is one of the main challenges in CPR management (Ostrom, 1990).

Appropriation problems may arise by either the subtractability characteristic of the common-pool resource itself (appropriation externalities), by a heterogeneous distribution of resources (assignment problems), and by differences in technologies used for appropriation or technological externalities (Ostrom, 1997). For example, an appropriation externality arises in irrigation systems where increased withdrawal by one pumper reduces the water other pumpers obtain from a given level of investment in pumping inputs. Similarly, a technological externality arises when some water users utilize more efficient water pumps imposing additional costs to other water users. If the distribution of water units is patchy, in which patches may differ dramatically in yield, assignment problems arise. Within irrigation systems, this is known as the traditional conflict between head-end and tail-end irrigators (Ostrom, 1997). For irrigators, long-run locational advantages and disadvantages may be either capitalized into land values (if land markets function reasonably well) or in strategic opportunities of getting the water first (Bardhan and Dayton-Johnson, 2002).

On the other hand, provision problems are classified into 'demand-side and supply-side related' (Ostrom, 1997:12). Demand-side provision problems arise from the way that appropriation impacts on the productive capacity of the resource. For example, a group of water users utilizing groundwater basins located adjacent to oceans may withdraw water to a level that permits the intrusion of salt water, destroying the capacity of the basin to hold potable water (Blomquist, 1997). The source of supply-side provision problems lies in the individual incentives to free-ride on the provision activities of others. Head-enders have a built-in advantage, in that they can prevent tail-enders from receiving water. On the other hand, head-enders need the tail-enders labour for repair and maintenance of systems. Maintenance to keep an irrigation system operating effectively may suffer from free riding because it may be difficult to monitor or prevent access (as it is with most public goods).

Physical environments may add complexity in solving the appropriation problems described above. Schlager (1997:251) argues that appropriation dilemmas meeting three criteria are likely candidates for possible solutions, namely: 'repeated encounters under similar situations in which opportunistic

individual behavior is seen to destroy the possibilities for collective gain; an information network that may arise from different types of interactions such as trading and competition – that forms the basis for the identification and negotiation of possible rules; collective means for the enforcement of these rules'. In these circumstances the gains from cooperation typically outweigh the gains from defection.

A large body of empirical work on CPR has focused on the analytical and structural elements that comprise successful management of appropriation and provision problems, in terms of various efficiency, equity or sustainability criteria (Baland and Platteau, 1996; Ostrom, 1990). These mainly include considerations over resource system characteristics, group characteristics, institutional arrangements, and the external environment including technological and centralized authority factors. Agrawal (2002) offers a synthesis of enabling conditions for sustainability of the commons. The author defines sustainability of the commons as 'the durability of institutions that frame the governance of common pool resources' (2002:44). These conditions include: small group and resource size; well-defined group and resource boundaries; shared norms and past successful experiences (defined by Agrawal as social capital); appopriate leadership and interdependence among group members; homogeneity of identities and interests among group members; overlap between user group residential location and resource location; high levels of dependence by group members on resource systems; and, fairness in allocation of benefits from common resources.

It is important to mention that CPR problems involve additional resource aspects, not jut resource size. Agrawal (2002:54) state that 'the limited attention to resource characteristics is unfortunate'. The mobility, volatility and unpredictability in the flow of benefits from a resource, may all impact on levels of regeneration, use and management (Dolsak and Ostrom, 2003). Blomquist *et al*. (1994) focus on two physical features of resource systems, stationarity and storage. Stationarity refers to whether a resource is mobile and storage concerns the extent to which it is possible to 'collect and hold resources' (1994:309). Stationarity implies that 'resource units yielded by the resource (usable amounts of water, oil, fish, etc.) remain spatially confined prior to harvest, or at least travel so slowly as to be fixed for all practical short term purposes' (Ostrom *et al.* 1997:308). Nonstationary resource units include water moving in a surface stream or canal, wild animals and most fish. Storage is related to stationarity, in a sense that storage can be used to retain resource units that would otherwise be mobile (Ostrom *et al*., 1997).

After examining the impacts of storage and stationarity on appropriation externalities and provision issues, the authors conclude that they have an impact on management because of their relationship to information (Blomquist *et al*., 1994). Greater mobility of resources and difficulties of storage make it more difficult for users to adhere to institutional solutions to CPR dilemmas because of 'their impact on the reliability and information costs needed for such solutions' (Agrawal, 2002:56). The physical caracteristics of stationarity and storage are linked to systematic differences in user's strategies and in the institutional arrangements developed to overcome appropriation and provision problems, as well as in the kind of information they have about these problems. This point can also be made regarding the extent to which resource availability is predictable, and how unpredictability affects the abilities of users to allocate available resources or undertake activities that would augment supply (Dolsak and Ostrom, 2003).

Baland and Platteau (1996:228) suggest that awareness of ecological stress builds up more easily with respect to a 'localized, visible, and predictable resource than in the case of a resource that stretches over vast and seasonally changing geographic areas, is largely unpredictable, and hardly visible'. In other words, in more predictable resource systems, communities are better able to obtain information (i.e. environmental feedback) and thus react accordingly. The authors present case studies in groundwater management where local users are 'typically' misinformed about ecological stress and the mechanism of resource overexploitation. They mention that in these cases:

> *'It is hard to know who is using the resource, how much water users are extracting, and what the relationship between actions and consequences is. The problem is again exacerbated by the fact that wells and pumps tend to be located on private lands and individually owned. In this context, it*

is extremely difficult for an understanding of resource dynamics to emerge at a community level. Individuals may understand the behaviour of their own wells but they are rarely able to put this behaviour in the context of other's use patterns at least until major disruptions have already occurred' (1996:230).

When a common-pool resource is part of a complex system (e.g. marine fisheries, climatic patterns), information on the system becomes available only over time (Dolsak and Ostrom, 2003). Increasing levels of environmental uncertainty may not only exacerbate CPR dilemmas, but also raise perverse incentives and expectations. Barnett and Adger (2003) found that institutions for collective action in resource management will tend to change their practices when there are expectations of future resource degradation due to greater uncertainty associated with climate change (Barnett and Adger, 2003). Uncertainty may also challenge the manner in which the diversity of social actors interpret as being a more sustainable outcomes in CPR use in the wake of environmental change (Leach *et al.*, 1997:93). The authors argue that 'different social actors may have different ideas on what (e.g. resources) should be sustained, and for whom (e.g. households, future generations, land owners, etc.)'. Wilson (2002:335) complements this assertion by stating that in more complex systems, 'learning the appropriate kind and extent of restraint required for sustainability is definitely a more difficult problem than one might be led to believe'.

Kopelman et al. (2002) argues that environmental uncertainty decreases the ability of communities to manage a CPR, by presenting experimental evidence that confirms the fact that environmental uncertainty about the pool size and replenishment rates lead to greater probability of overuse of common-pool resources. She offers three possible explanations for increased variability leading to overuse. The first is that increased variability of the pool size makes 'people think that other's requests also will be more variable' (2002: 126). This means that individual behaviour becomes less predictable in face of uncertainty. Secondly, empirical evidence supported the hypothesis that different types of people (individualists versus co-operators and altruists) perceive environmental uncertainty differently. While individualists had a tendency to increase harvesting rates under conditions of uncertainty, co-operators held their harvest constant, or harvested less. A third explanation offered by the author, is that in situation of uncertainty, people may overestimate the size of the pool. This may become an 'external justification for their over-harvesting behaviour, and therefore, uncertainty may also act to diffuse personal accountability' (2002: 126).

McCay (2002) associates the issue of environmental uncertainty with the ability of individuals and communities to perceive risks. The author mentions that 'problems affecting the sustainability of natural resources or the viability of livelihoods based on those resources may be viewed as situations of risk: the risk of loosing access to and the use of something valuable and essential to the life of a person, a family, a community…how societies are affected and perceive these risks is critical to whether and how they respond, including responses that affect the emergence of institutions for reducing or preventing those risks (2002:364). McCay acknowledges that some kinds of CPR problems are inherently difficult to perceive and assess, such as those that are 'diffuse, mostly invisible and intangible, and not easily associated with particular consequences' (2002:366).

CPR issues affected by environmental change may be compounded by uncertainty associated with property right systems, in what Dasgupta (2001) defines as a type of institutional failure. The author argues that when people are uncertain of their rights to a piece of property, they are reluctant to make the investments necessary to protect and improve its performance through time. Expectations of low returns not only may hamper the prospects of collective investment (e.g., to build an appropriate irrigation infrastructure), but also in reducing risks associated with environmental change. The author argues that the distribution of property rights in a community 'enable members of a group to reduce individual risks by pooling their risks', and that 'the incentive to pool risks that are associated with the use of any particular resource depends on the other risks people face; it depends on their remaining sources of income, on transaction possibilities in other spheres of life, and so forth' (2001:110).

To manage for CPRs in highly variable and uncertain environments, is to devise institutional arrangements that promote social resilience and adaptive capacity (Wilson, 2002). Social resilience may be defined as the 'ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change' (Adger, 2000: 347). Social vulnerability is the exposure of groups of people or individuals to stress as a result of the impacts of environmental change. Stress, in the social sense, encompasses disruption to groups' or individuals' livelihoods and forced adaptation to the changing physical environment. Resilience comes from flexibility, and the ability to change adaptively (Levin *et al*., 1993). According to Adger (2003b:1), 'promoting resilience means changing, in particular the nature of decision-making to recognize the benefits of autonomy and new forms of governance in promoting social goals, self-organization, and the capacity to adapt'.

The adaptive capacity of all levels of society is constrained by the resilience of their institutions and the natural systems on which they depend. The greater their resilience, the greater is their ability to absorb shocks and perturbations and adapt to change. Conversely, the less resilient the system, the greater is the vulnerability of institutions and societies to cope and adapt to change. Social-ecological resilience is determined in part by the livelihood security of an individual or group. A resilient social-ecological system, which can buffer a great deal of change or disturbance, is synonymous with ecological, economic and social sustainability. One with low resilience has limited sustainability; it may not survive for a long time without flipping into another possible qualitative state (Berkes *et al.*, 2003).

The prospects of climate change offer an additional challenge for the successful management of already environmentally endangered CPRs. Available observational evidence indicates that regional changes in climate, particularly increases in temperature, are affecting a diverse set of physical and biological processes (IPCC, 2001). Associations between changes in regional temperatures and observed changes in bio-geophysical systems have been documented in many aquatic, terrestrial, and marine environments. Social systems, likewise, are being impacted by recent increasing frequency of floods and droughts in some areas (for example, Mortimore and Adams, 1999; Dixon *et al*., 2003; Barnett, 2003; Adger, 1998).

In face of this challenge, learning from past and present adaptation strategies becomes empirical in order to understand both the processes and limitations of the adaptive dynamics of social and environmental systems (Adger, 2003b). According to Adger (2003b), adaptation processes are subject to the interdependencies of agents, the institutions in which they reside and with the resource base on which they depend. The building of adaptive capacity of social and environmental systems in the context of increasing climatic variability becomes of central importance to reduce the condition of environmental degradation and social vulnerability (Tompkins *et al.*, 2003).

2.5 History and Water Availability in Northeast Brazil

Variations in water supply due to increased climatic variability and change will have more serious effects on some societies than on others. Martinson *et al*., (1998:10) argue that 'less developed countries, particularly those with semi-arid climates, marginal agriculture, and rigid social structures, are clearly vulnerable to growing season failures'. Climate varies seasonally, inter-annually, and on decadal and longer time scales. Depending on the particular region of concern on the Earth's surface, climate variability can range from small to large. Precipitation in arid areas, for example, is skewed to dryness, with a few rainfall episodes that are far above average being balanced out by a larger number of below-average rainfall events; conditions that are statistically average seldom occur. Researchers speculate that with global warming of the atmosphere there will probably be an increase in drought-related crop failures in areas already subject to drought. They contend that dry areas, such as northeast Brazil, will get drier and wet areas wetter (Oyama and Nobre, 2003).

The history of northeast Brazil is full of examples of major failures of growing-season rainfall, in a cycle described by Glantz (1994) as the 'drought follows the plough effect'. Intensive human use of land resources commenced within the colonial period (16th century). Since then, attempts to manage the landscape with the prime motive of withdrawing commodity items such as sugar and cattle in face of unfavourable climatic and physiological conditions framed human-environmental relationships. Three historical moments are the most conspicuous in the geographical occupation of the Northeast: the colonial production of sugar-cane; an intensification of cattle raising activities, and the introduction of irrigation systems (Suassuna, 2002).

In the beginnings of colonial time, the sugar-cane based population settled in areas relatively rich in natural resources along the Atlantic coast far into the *Agreste*. Cattle were introduced by the colonialists, and soon extensive areas were settled for cattle-raising activities. As agricultural and ranching activities intensified, human settlers were pushed into the semi-arid regions, which offered vast land extensions with suitable vegetation-types for cattle-raising. Artificial pastures were established in most of the human affected localities. From exploiting environmental resources within established ecological systems, humans actively re-organized ecosystems in order to maintain and augment economic output. The ecology of the semi-arid regions was transformed into agro-ecosystems dispersed over all of its territory.

With the intensification of human activities in the region, water became a scarce element. Efforts to improve water storage capacity and availability were introduced by the Brazilian federal government in the beginning of the 20th century. Large water reservoirs built with public funds were mainly centred on large estates owned by influential elites, where most of the peasant families lived and worked. Thus, water resources controlled by powerful landowners framed working and living relations between the elite and the rest of the population. The construction of water reservoir coupled with extensive irrigation systems allowed an increase in agricultural and cattle-raising activities at the expense of further environmental degradation.

Patterns of land ownership and land-use were established hundreds of years ago during Brazil's colonial period. Since the colonial period, basically two types of land ownership in the region exist: large estates and small subsistence landholdings. Subsistence farming takes place on small holdings or on land leased to poor farmers on large estates. Current population growth and the expansion of cattle raising activities in the region, continue pushing farmers into increasingly marginal areas, with low agricultural productivity (Glantz, 1996).

Agricultural activity in the semi-arid regions, predominantly based on small producers, landowners or tenants, and waged workers who produce for their own subsistence, is periodically plagued by short term droughts, and multi-year dry periods. Droughts occur under the form of severe decreases in precipitation levels or most importantly, by the spatial and/or temporal concentration of precipitation at a given year. During severe drought periods, agricultural output is lost, cattle raising activity is diminished and water reserves are depleted. Landowners and tenants (known as *latifundistas*) lay off their workers as a temporary cost-saving measure, while more vulnerable segments of the population attempt to rely on government-led initiatives (such as temporary work-fronts) or simply migrate into other regions of Brazil or to urban centres of the Northeast.

In the 1970s and 1980s, migration patterns from the northeast to the Amazon region resulted from a number of factors including drought events, the land-tenure structures, changes in economic performance and labour demand (Bitoun *et al.*, 1996). During the 1970s three drought periods (1970, 1976 and in the period of 1979-1983) had significant impact on economic output, disrupting agricultural production and accelerating out migration from both the rural and urban areas of the northeast (Bitoun *et al.*, 1996). The number of skilled-workers enlisted in government-led programs increased, and those who could not find temporary wages were expelled from small-scale farming arrangements, by either famine or landlords seeking to spread sugarcane and cattle ranching activities into new areas. Each drought event diminished the abilities of small landowners and landless

producers to cope with their subsistence needs even in times of normal rainfall patterns (Ribot *et al.*, 1996). Food and debt payment constituted an increasing share of the drought-stricken marginalized populations, leaving them unable or barely able to subsist.

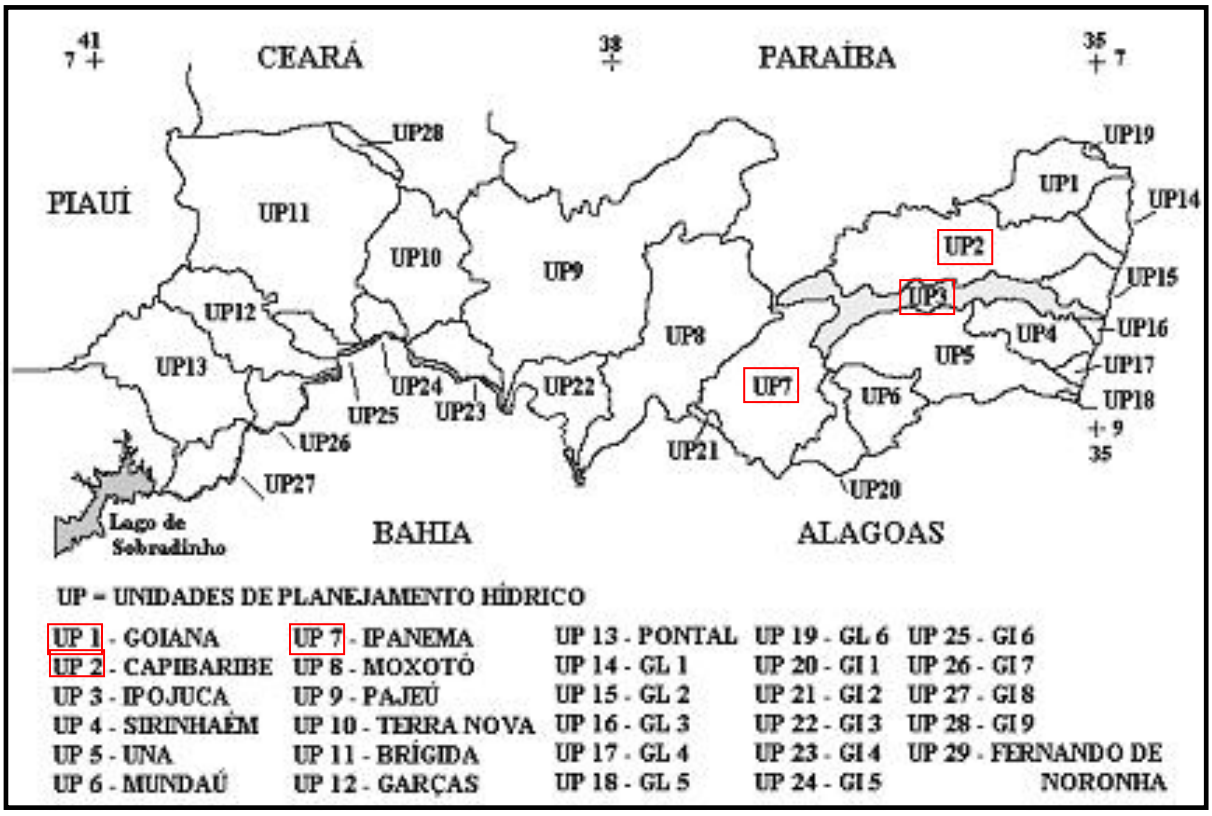
In the 1990s, the pattern of unequal land distribution as well as working arrangements in the Northeast persisted (Duarte, 1999). In a survey conducted by the National Institute for Agrarian Reform and Colonization (INCRA) in 1992, revealed that rural establishments with less than 50 hectares represented 75% of all existing land titles and less than 12% of all area. In the other extreme, rural estates with over 200 hectares were claimed by only 7% of all land titles in the region and covering over 68% of the total area. It was surveyed on the same year, that in properties with less than 50 hectares, rural workers were either owners or partners, while in properties over 200 hectares, the far majority of rural workers received either payment for work or were engaged in some form of partnership. That is, fragile working arrangements continued to persist despite past episodes of mass lay-over by tenants and landlords.

Drought periods that occurred in the 1990s resembled those of the 1970s and 1980s in both severity and consequences (Duarte, 1999). Because of the 1998-1999 drought event, more than 1.2 million rural workers subscribed to the government-led work fronts program. A survey conducted by FUNDAJ in order to evaluate the social-economic impacts of this drought event, concluded that more than 70% of interviewed workers at the work fronts had previously worked in similar programs. This index alone demonstrates the continuity of patterns and consequences of drought periods in the semi arid regions of Northeast Brazil, much into the 20st century. Magalhaes and Magee (1994:72) state that 'these improvements, however, cannot hide the fact that overpopulation and economic overexploitation, and a resultant incorporation of marginal lands into agricultural production, has made poor people in the semiarid region more vulnerable to the impacts of future droughts. Paradoxically, while the ability of federal and state governments to respond to drought has improved, the vulnerability of ecosystems and inhabitants in the northeast has increased. The end result has been that, nowadays, even rather minor meteorological droughts can have major societal and ecological impacts, whereas in the past only major droughts became major problems. In other words, it seems that previously there was a greater resilience to small climate variations'.

To support agricultural practices at relatively low cost and with minimum environmental impacts, small scale communal irrigation areas have been established in Brazil over the last 20 years. Brazil's Government agencies are responsible for the execution of this initiative, the installation of a basic infrastructure, the management of the system, and the provision of technical support to the farmers. The farmers, based on the directives of the projects under this initiative, are responsible for the cultivation and harvest of the crops. In addition, the Government agencies should carry out field surveys at the irrigation sites to continuously check relevant aspects which may affect the performance of each project, such as water quality and quantity, and soil conditions for cropping. However, a lack of financial resources usually constrains monitoring at project sites. Many of the projects in the semi-arid Northeast of Brazil are based on the use of the water from the localised alluvial deposits, which are found adjacent to the small streams that traverse the region. The selected project areas are located along ribbon valleys in Pernambuco State that traverse the crystalline formations which underlie more than 84% of the land area.

For water resource management purposes, Pernambuco State has been divided into 29 UPs (water resource planning units), which relate to single watersheds or groups of small watersheds (Figure 2.1).

Figure 2. 1 Water Resource Planning Units in Pernambuco State



2.6 Community Management of Water Resources

Publication 35 entitled 'Community Water Management' of IIED (International Institute for Environment and Development) provides an excellent overview of participatory approaches in community management of water resources from a global perspective. The global perspective in relation to the Project goal and purpose needs to be further explored.

The APWELL project in India also provides a case study of the establishment of local community responsibility for groundwater resource utilisation and management. Participatory Hydrological Monitoring (PHM) was introduced to develop awareness amongst the groundwater users of judicious use of the available resource. The project lists as its objectives of PHM:

- *Creating awareness on groundwater resource availability*
- *Establishing the local micro catchment level rainfall-recharge relationship*
- *Develop appropriate water use plans matching with the utilizable groundwater reserves*
- *Establish need for conservation of groundwater and need for increased recharge*

The APWELL project clearly highlights the significance of monitoring and understanding of resource availability and vulnerability. This knowledge should be seen as one of the major pillars supporting the long-term sustainable use of the resource.

2.7 Specific Water Resources Studies in Northeast Brazil

2.7.1 The World Bank

The World Bank has assisted Brazil in developing institutional capability in water resources planning, management and protection. The partnership between the World Bank and Brazil has helped in the National Water Policy, which was enacted in 1997. The World Bank's main objective is the alleviation of poverty through supporting of initiatives for sustainable and equitable development.

The World Bank has worked in the water sector in Brazil since the early 1970's, particularly in water supply, sanitation and irrigation. Projects are generally large-scale at state or river basin level. Projects under implementation include the following:

- Federal water resources management projects – PROÁGUA Semi-Arid (Loan 4310-BR)

  This is a Brazilian Government programme, which aims at structuring the water resource sector, particularly strengthening the institutional capability of the Secretariat of Water Resources in the Ministry of the Environment (MMA), State Government organisations, river basin committees and other stakeholders. The general objective of the project is to improve the supply of good quality water to the semi-arid region. Specific objectives include:

  - The promotion of efficient and sustainable use of water resources
  - Emphasis decentralisation and participation in water resources management
  - Promotion of safe drinking water to communities
  - Promotion of the preparation of high-quality technical studies, projects, river basin plans, feasibility studies, etc., that favour the development of new investment projects
  - Develop mechanisms and processes for the administration, operation and maintenance of water infrastructure in the Northeast

- Water sector modernisation II project (Loan 4292-BR)

  This project is largely focussed on institutional reform.

- PROSANEAR II technical assistance project (Loan 4532-BR)

  This project involves assistance to the Brazilian Government in extending basic water supply and sanitation services to the poor, mainly in metropolitan areas throughout the country.

- Federal water quality and pollution control project (Loan 3503-BR)

  This project was completed in 1999 and has resulted in investment plans for four major urban river basins throughout the country. The studies were carried out for river basins amongst others in the Recife metropolitan area in the State of Pernambuco.

- Land Reform and Poverty Alleviation Pilot Project (Loan 6475-BR)

  Brazil has one of the most unequal distributions of land ownership in the world. Limited access to land and extreme inequality in land ownership are central factors contributing to rural poverty in Brazil. The Northeast Region, where the Land Reform and Poverty Alleviation Pilot project will be located, holds the largest concentration of rural poor in both Brazil and Latin America in general. The aim of this project is to reduce rural poverty in the region. The project is consistent with the Bank's Country Assistance Strategy (CAS) for Brazil, which identifies poverty reduction as the central objective of the Bank's assistance efforts. The CAS recommends specific anti-poverty policies. Accordingly, this project will assist the Government of Brazil in alleviating rural poverty and its consequences by providing rural poor with access to land and funds for complementary investment

subprojects. These subprojects will then be planned and implemented by community associations. The project will also support experimentation with a program of market-assisted land reform in which beneficiaries are given access to financing for the purchase of suitable lands negotiated between the willing sellers and willing buyers.

The project seeks to reduce rural poverty in Northeast Brazil by: i) increasing the incomes of about 15,000 poor rural families through improved access to land and participation in complementary, demand-driven community subprojects; ii) raising the agricultural output of lands included in the project; and iii) pilot testing a market-based approached to land reform in which beneficiaries obtain financing for the purchase of suitable properties negotiated directly between rural communities and willing sellers.

The main project benefits will be the sustainable increase in the incomes and quality of life of about 15,000 poor farmer families previously without land or with insufficient land for subsistence. In addition, the project's poverty alleviation component will generate economic benefits in the form of increased agricultural output on the lands that are being acquired by beneficiaries.

The full participation of women is critical to the poverty objectives of the project. Bank supported operations and studies in the project region reveal a strong correlation between the problems and needs of rural women and those of producers and family units in general. They also show that community leaders in the Northeast, where the project will be located, favour women's participation due to their willingness to provide assistance and services, receptiveness to change, and greater likelihood of repaying debt. This project will seek to ensure that women's activities (both traditional and innovative) are included: i) to support subprojects which foster maternal/child health and day care facilities; ii) to target groups and activities in which female participation has proven constructive; iii) to provide technical assistance for women's subprojects proposals and implementation; and iv) to monitor women's participation in the project and its benefits.

A participatory approach was used in project identification/preparation, implementation and operation involving project beneficiaries/community groups, intermediary NGOs and State/Local governments.

2.7.2 PROASNE

PROASNE (Northeastern Brazil Groundwater Project) is a CIDA (Canadian Government) sponsored initiative, which started in 2000. Brazilian collaborators include the Serviço Geológico do Brasil (CRPM) of the Ministério de Minas e Energia. The specific objective of the project is *to provide Brazilian institutions with tools and know-how to explore and better manage the groundwater resources of the region*. The project operates in pilot areas in three states in the Northeast Region; Ceará, Rio Grande do Norte and Pernambuco. Adèlia de Melo Branco has been involved with gender work.

The project involved technical and social components, which were (personal communication) not fully integrated at the onset of the project. A fuller integration was included in a revised log frame after the inception stage of the project.

The project considers sustainability from two angles; the sustainability of technology transfer to the Federal and State institutions, and the sustainability of ‘low’ technology transfer to the communities. For both angles, the potential lack of financial resources in the longer term is seen as a risk to the success of sustainable development.

2.7.3 Other Initiatives

Two NGOs of the north-east, ESPLAR and CAATINGA, are developing and divulging proposals for improving strains of cattle and goats for small farmers working in semi-arid regions, and for the rational use of the vegetation of the Caatinga, also in partnership with EMBRAPA.

The Advice and Services for Projects in Alternative Agriculture (Assessoria e Serviços a Projetos em Agricultura Alternativa AS-PTA) has set up and adapted methodologies for participative analyses for local development projects. One of these, the Rapid and Participative Agrosystem Diagnosis (Diagnóstico Rápido e Participativa de Agrossistema _ DRPA) is being applied by various NGOs in a number of ecosystems;

The programs that PTA supports are selected by the state governments and their partners. All are geared towards sustainable development and contain a technological innovation component, in addition to displaying financial, social, environmental and cultural viability. The programs foster an exchange of academic, technical and community knowledge in an effort to increase the contributions of each of these sectors.

Actions undertaken are planned by state governments, partner institutions and small-scale producers to increase the potential and minimize the problems of diverse technological sectors. To guarantee the feasibility of the undertakings, states make personnel, facilities and resources available to producers, and provide assistance throughout the implementation process.

The agreements that CNPq has signed with the states under the PTA umbrella have made it possible to launch small-scale business undertakings. This involves contracting highly qualified technicians through technological support grants to ensure contributions by specialists in a variety of fields.

Effective development of sustainable projects depends on science, technology and human resources development. The workforce is trained in the most appropriate technologies for tackling the obstacles encountered in making small businesses operational. Strategies combine education and work.

PTA has divided its action into three major fields: data, production and extension.

The program centralizes data gathering, selection and transfer, and dissemination of appropriate technologies, while seeking to find mechanisms for making them widely available.

The program focuses on technological innovation activities, fostering generation of appropriate technologies through formal channels in areas of technology and science, awarding study grants, publishing theses and technical books, promoting events focusing on scientific and technological issues and, above all, developing research.

The program involves support for experimental activities that enhance the integration and participation of the community, including creation of training programs and demonstration units. Such activities aim at fostering an understanding that the best technologies chosen for implementation are those selected by the group that uses them.

2.7.4 Underground Dams

In semi-arid northeastern Brazil underground dams that cost 500,00 USD permit a farmer to have half a hectare to one hectare of moist soil during the dry season, which is used to produce cereals, vegetables, fruits and fodder guaranteeing food security in critical periods.

The wall of a submerged dam, on the other hand, is entirely enclosed in the alluvium, and water is stored in the saturated soil. These types of dams have been built in northeast Brazil since the turn of the century to augment rural water supplies.

Level of Involvement

Underground dams are under construction throughout the semi-arid region of Brazil, with funding from state and municipal governments and from farmers.

Costs

The costs involved in building underground dams vary depending on such factors as length of the wall, materials used, depth of the impermeable layer, and availability of manpower. An underground dam with a drainage area of 1.0 ha, built with a polyethylene plastic canvas wall, costs an average of $500.00. If 4mm PVC canvas is used for the wall instead, the dam will cost about $1 700.00.

Effectiveness of the Technology

Although simple to build, underground dams must be constructed with considerable care if they are to work effectively. For example, the dam wall should extend all the way down to the impermeable layer to prevent seepage; when plastic canvas is used for the wall, every effort should be made to prevent punctures, and, should they occur, the canvas should be patched with a piece of the same plastic and an appropriate glue. The canvas should never be left uncovered and exposed to direct sunlight, as it easily dries out and may split. A drainage ditch should also be provided as a means of managing the salinity of the impounded water.

Suitability

Underground dams can be introduced throughout the semi-arid region. Given the agro-ecological and socio-economic conditions that inhibit agricultural development in the area, this technology has the potential to take maximum advantage of the available water. Underground dams have been accepted throughout the semi-arid northeast region of Brazil because of their benefit to users. Their use is primarily by farmers, owing to the relatively high cost of building them.

Advantages

- Underground dams are based on a simple technology, are inexpensive to build, and can make use of locally available materials and manpower.
- Once water has been stored in the alluvial soils, they have low evaporation rates compared to surface water reservoirs.
- They can be combined with other technologies, such as soil and water conservation techniques, and dug wells upstream.

Disadvantages

- Because underground dams store water within the alluvial soil profile, their capacities are low compared with those of conventional dams.
- Given the socio-economic circumstances of farmers in the semi-arid tropical region of Brazil, the cost of building these dams is a real obstacle to the widespread adoption of this technology.

Da Silva MS et all investigated the agricultural exploration on underground dams. A summary of there research is included below:

Underground dams are a water resource alternative for storage of rain water on the soil profile, allowing its use through receding agriculture and/or sub-irrigation. The objective of this study was to evaluate the physical characteristics of the soil and electrical conductivity of the water stored in the reservoir of each dam after eight years of management, the production of fruits and cowpeas, and the costs of darns and crops. In 1982, four underground dams were constructed where maize, cowpeas and sorghum were cropped, at the Experimental Station of Embrapa-CPATSA, Petrolina, PE, Brazil. in 1987, perennial crops were introduced: mango, soursop, lemon, guava and acerola. After eight years of underground dams management, the data showed low risk of salinity, increased clay content on soil due to sedimentation and no density variation. The yields of 3,000, 2,000, 3,000, 2.000, 800 and 578 kg/ha, respectively, of mango, soursop, lemon, guava, acerola and cowpeas, associated with low cost and easy management of dams recommend them as a viable alternative for crop production in semi-arid regions.

2.8 Project Area Specific Reports

SALT ORIGIN AND SALT DYNAMICS ON THE CRYSTALLINE GEOLOGIC DOMAIN , AND SMALL-SCALE ALLUVIAL DEPOSITS- THE ROSARIO FARM DEPOSIT – Abelardo Montenegro

Introduction

The high salinity in fissured aquifers and alluvial deposits is a limiting factor for small-scale agriculture development in the Brazilian Northeast. **Costa (1965),** and **Siqueira (1967)** attributed the groundwater salinization process in the crystalline domain and some fluvial valleys to the mineralization by natural dissolution of the aquifer's rocks, enhanced by the high regional temperatures. This hypothesis was questioned by **Cruz and Melo (1968),** who alternatively suggested that groundwater evaporation by capillary flow, associated with the usually low hydraulic conductivity of the fissured formations, is the main mechanism leading to salt build-up. This was considered relevant to these regions, with low rainfall and higher atmospheric temperatures. In the alluvial valleys, where the hydraulic conductivity is higher and groundwater circulation is enhanced, lower salt contents are observed. An attempt to explain the salinisation process in the crystalline region was made by **Matsui (1978),** who considered the influence of air-transported sea salts on the solute mass balance for the aquifers. According to isotopic data (^{18}**O** and Deuterium) in Pernambuco State, **Matsui (1978)** verified that the groundwater in the region's fissured aquifers exhibits moderate evaporation when the water table is not close to the soil surface. This result contrasts with the hypothesis formulated by **Cruz and Melo (1968),** about the importance of the capillary discharge on the progressive salinization in the crystalline domain, even for deep water tables. Further analysis of the **Cruz and Melo (1968)** data, carried out by **dos Santos et al. (1984),** identified that the observed areas with high total salt concentration were located in saline soil regions having clays with a high cation exchange capacity and that are sodium rich, in particular the Brazilian Vertisol and Solonetz soils. Several soil associations where studied by **dos Santos et al. (1984).** Highly saline groundwater was found underlying soils of Regosolic type associated to Planosol, with a fragipan (impediment layer), and Podzolic associated to Planosol and Solonetz. Conversely, Litholic soils and Yellow and Red Podzolic soils were usually associated with groundwater exhibiting low to moderate salt content. **Molinier et al. (1989)** observed total salt content increases of about fifty times between the rainfall water and the drainage to groundwater at the base of an 80cm thick Vertisol soil (with swelling clays

with high cation exchange capacity), in Paraiba State. It was also shown that the groundwater mineralization resulting from the aquifer's chemical constituents was negligible on a time scale of years. According to **Leprun (1983),** based on 504 chemical analyses of water samples from rivers and reservoirs, the Brazilian Planosol and Solonetz soil groups pose the highest salinization and sodification risk to surface water and subsurface water, and significant hydrogeochemical changes are likely to occur. The Alluvial sandy soils and Yellow and Red Podzol are usually associated with good quality water.

These results highlight the central importance of soil identification on the sustainability of irrigated agriculture. Descriptions of the soil groups relevant to the Brazilian Northeast (based on the FAO/UNESCO Classification System) can be found in **Molle and Cadier (1992)** , **Braun and Kruijne (1994),** and **Montenegro (1997).**

THE CASE -STUDY ALLUVIAL DEPOSIT

The 'Nossa Senhora do Rosario' farm is situated in the Pernambuco State, with geographic coordinates 8^{o} 24' 11" south latitude, and 37^{0} 48' 54" west longitude, and 630m average altitude above sea level (**CISAGRO, 1991**). The farm is located near to the town of Pesqueira, 220km from Recife (the Capital of Pernambuco State), and is located in the Ipanema river valley. Land reform in the area was implemented by the Pernambuco State Government, providing cropping plots of approximately 2 hectares to local families. The 'Nossa Senhora do Rosario' farm community project also involved public investments to provide pumping wells, and sprinkler irrigation installations. Small-scale irrigated agriculture on the communal farm using groundwater commenced in December, 1991.

Irrigated agriculture has been developed on the main fluvial valley, formed by the non-perennial Mimoso and Jatoba' rivulets. The alluvial valley presents a natural topographic slope of about 0.3%, being bordered by granite and gneiss rocks of the crystalline formation. The underlying alluvial aquifer is relatively shallow, about 10m deep, 300m wide, and 15 km long (**CONESP, 1988**). The aquifer is a fine to medium heterogeneous sand deposit, containing some fine material (silt and clay). The dominant soil type in the valley is Alluvial soil, whereas on the hillslopes Yellow-Red Podzolic and Litholic soils are present. Although Planosol soils can be identified near Pesqueira, they do not occur within the 'Nossa Senhora do Rosario' farm.

Directives for groundwater exploitation by wells were produced by **CONESP (1988), HIDROPIRES (1990),** and **CISAGRO (1991).** The original irrigation project comprised the installation of four large diameter wells ("Amazonas" type). Table 1 presents the water quality of these wells, during the dry season of 1989 and the rainy season of 1990.

Table 1- Groundwater quality in the alluvial aquifer, from HIDROPIRES(1990) and CISAGRO(1991) (* SAR represents the sodium adsorption ratio).

well	%[Cl^-]		%{[Na^+]+ [K^+]}		TDS (meq/l)		EC(dS/m)		SAR*	
	Nov 1989	Jul 1990	Nov 1989	Jul 1990	Nov 1989	Jul 1990	Nov 1989	Jul 1990	Nov 1989	Jul 1990
P1	69	63	53	57	13.41	6.41	1.35	0.65	3.84	2.50
P2	61	65	60	64	10.33	10.86	1.05	1.00	4.18	4.88
P3	60	62	72	60	10.30	9.67	1.05	0.95	5.89	4.19
P4	59	55	67	52	10.90	7.50	1.10	0.70	5.38	2.96

According to the classification suggested by the U.S. Salinity Laboratory Staff **(Richards, 1954)** for irrigation water, the groundwater near all the wells were **C3S1** in November 1989, and July 1990 (except at wells **P1** and **P4**, in the rainy season of 1990, which was classified as **C2S1**). Since all the analysis lead to water **S1** type, it can be concluded that the risk of sodification in the valley resulting from irrigation water pumped from the wells is very low. Irrigation water type **C2** has intermediate salt content, whereas water type **C3** requires salinity management and can be used for salt-tolerant crops only. Using the Piper diagram for chemical classification (see, for example, **Domenico and Schwartz (1990)**), the groundwater in the Mimoso alluvial deposit is of sodium chloride type, which is the dominant water in the crystalline domain (**Cruz and Melo, 1968**).

Pesqueira region is located in the "Agreste" region, exhibiting a very-hot semi-arid climate.

The main irrigated crops in 'Nossa Senhora do Rosario' farm, as proposed by **CISAGRO (1991),** are carrot, sugarbeet, tomato, and green pepper. **CISAGRO (1991)** suggested September as the cultivation period for all the crops, with harvest occurring in November/ December. According to the field evidence, the original cropping schedule has been approximately followed by the farmers. Some adaptation has occurred, in particular the insertion of an additional carrot season during the dry period. The total irrigated area is about 30 hectares. Saline crusts can be observed in some parts of the alluvial valley.

Recently, a joint project involving the Federal Rural University of Pernambuco State, the Federal University of Pernambuco State, and FUNTEPE, which is the State Organization for land reform, has implemented 12 ha cultivated with banana, and using efficient irrigation methods.

Despite the large investment in the 'Nossa Senhora do Rosario' area, and the poor quality of the irrigation water, salinity monitoring and management procedures have not been fully implemented at the farm. Studies have not completely identified areas of the Mimoso valley exhibiting higher salt contents in soil and groundwater, and the impact of irrigation practices on the local environment. The definition of management alternatives to be conducted by the farmers should concentrate on datailed hydrogeological and hydrological characterization of soil and aquifer, including the identification of layers and the impediment beds. It is essencial to define the limits of the watersheds and also to characterize the land use and ocupation. In this context, knowledge transfer to the farmers and building capacity can be carried out.

3 Water Policy and Institutional Setup

3.1 National Water Policy

The present Brazilian National Water Resources Management System has been established through the Law 9,433 introduced on January, 1997, which also defined the National Water Resources Policy. The full text of the document is given in Appendix B. In 2000, the broad institutional reform of the water resources sector was consolidated by Law 9,984, which created the National Water Agency (ANA- Agência Nacional de Águas). Prior to this, the water resources management system functioned based on the 1934 Water Code and afterwards through the inclusion of the National Water Resources System in the 1988 Constitution.

The objectives of the National Water Resources Policy were established:

- to ensure the availability of water needed, at standards of quality appropriate to the respective uses, for present and future generations;
- to support the rational and integrated use of water resources, including waterway transport, with a view to sustainable development;
- to assist in the prevention and protection against critical events of a natural origin or resulting from the integrated use of water resources.

The National Water Resources Management System is intended to achieve the following objectives:

- to coordinate the integrated management of waters;
- to arbitrate water use- related conflicts administratively;
- to implement the National Water Resources Policy;
- to plan, regulate and control the use, conservation and recovery of water resources;
- to promote billing for water use.

The members of the National Water Resources Management System are:

- the National Water Resources Council
- the Water Resources Councils of the States and the Federal District
- the River Basin Committees
- the government agencies whose competencies are related to water resources management
- the Water Agencies

The new law represented the modernization of the water resources sector. According to the National Water Resources Policy, water is defined as a good in the public domain, with an economic value, whose priority uses are human and livestock supply, and whose management has as a territorial unit the river basin. Its general philosophy is integrated management, and the instruments enabling the implementation are water resources plans, classification of rivers into classes according to main uses, the concession of rights to its use, billing for water use and the system of information on water resources.

A major characteristic of the system is the importance assigned to public participation. The participation of users and civil society was ensured in all for a constituted by the system, ranging from the National Water Resources Council to the River Basin Committees as a way of legitimising the

decisions and also to ensure their implementation. Individual States also advanced rapidly towards instituting Basin Committees.

The constitutional existence of this National Water Resources Management System does not allow the States to organize the collection of taxes for different water resources uses without the implementation of Water Agencies and the formation of River Basins Committees. Through this model the "Federal System of Water Resources" and a "State System of Water Resources" are not isolated from one another and should produce compatible and convergent rules. The States are permitted to enshrine within their water institutions the particular issues and concerns applicable to the local region, as long as they respect the general characteristics of the National System, the Committees and the related agencies, which are pointed in the Federal law Nr. 9.433/97.

The Water Resources Secretariat of the Ministry of Environment performs the function of the Executive Secretariat of the National Water Resources Council (CNRH- Conselho Nacional de Recursos Hídricos), and provides technical administrative and financial support to the council.

The CNRH decides on the creation of River Basin Committees in rivers under federal domain, based on a detailed analysis of the basin and its sub-basin. The aim is to optimise the establishment of these entities. In such a way, the government has established minimum rules that allow the demonstration of acceptance by the society, of the real need for the creation of the various committees.

Following the national water resources regulatory framework, many states have already advanced laws and regulations on water resources. Currently, 18 States and the Federal District have proposed their own Water Resources Policy and Management Systems. The States have adopted diverse administrative structures for composing the water resources management system- SEGRH (State Water Resources Management System), most of them through joint Secretariats for water resources, environment, science and technology.

3.2 Legislation and Institutions at State Level

The water management in Pernambuco State has been developing under state law Nr. 11,426 since 1997. The acting legislation institutes the Integrated Water Resources Management System – SIGRH/PE, composed of the following:

- the Regional Water Resources Council – CRH;
- the State Water Resources Committee – CERH;
- River Basins Committees – CBHs;
- the Secretariat of Science, Technology and Environment of Pernambuco State – SECTMA, and
- other executive institutions (ITEP and CPRH) .

Under the state water resources regulatory system the state law Nº 11,427 (1997) address the needs for groundwater protection and conservation. The current state law does not foresee the formation of a State Water Agency, but constitutes a State Water Resources Committee, which is not included in the national legislation. The State Water Resources Council – CRH is the superior, normative, deliberative and counselling regional organization of SIGRH/PE.

Currently, Pernambuco has seven river basin committees (CBH are already established and working in the catchments of the rivers Pirapama, Pajeú, Moxotó, Mundaú, Jaboatão, Ipojuca and Una; and 5 constitutional User's Associations.

The User's Associations are groups recognized by the State Water Resources Council, and are formed by users of one same source, in general a surface reservoir. They have as main objectives: to promote the rational use of the water, to protect the water source and to avoid conflicts of uses and/or among users. The process of formation of User's Associations initiated from demand of the society, generally in response to water scarcity that normally generates conflicts between users.

The Secretariat of Science, Technology and Environment of Pernambuco State – SECTMA aim is to promote the social, economics and environmental development of Pernambuco State by the formulation and implementation of integrated public policy of technological innovation, higher and professional education, science development, environmental protection and conservation.

Since March of 2003, due to the extinguishment of the Secretariat of Water Resources, SECTMA is the executive secretariat in the Pernambuco State Water Resources Management System. In the scope of executive administrator SECTMA instituted the *Water Resources Integrated Management Programme* with the following objectives:

- to implement and to spread out the state water resources policy;
- to stimulate and support the creation of River basin Committees;
- the planning and management in different levels the water resources use in the state;
- To develop projects and studies which aim the optimisation of water resources uses;
- Management of climate and meteorological monitoring programmes.

Two other institutions are linked to SECTMA and perform activities related to the state Water Resources Management System and Policy:

- The Water Resources and Environment State Agency (CPRH), which is responsible for licensing the use of water, water resources and environment monitoring, development of environmental and water resources education programme;
- ITEP (Pernambuco State Technological Institute) supports the activities of meteorological and climate monitoring.

Table 1 presents the number of requests and permits for water uses in Pernambuco State (jointly analysed by SECMA and CPRH) since the institution of the state Water Resources Management Policy and System in 1997 (Silva et al., 2003). It is important stress that many of the requests have not been approved with the issue of licences. It can be seen that the groundwater has the majority of requests and given permits. The great majority of the groundwater requests are for the Recife Metropolitan Region, comprised of 13 towns.

It is important to note that according to the State law Nº 11,427 the following do not need a licence:

- wells less than 20m deep, and
- wells with a discharge rate of less than 5m^3/day. *(need to clarify if this is an average daily amount or a maximum)*

A review of the State law is currently undertaken and issues related to licensing are being considered. The review is scheduled to be completed by the end of 2004.

In the shallow alluvial aquifers of interest, all wells will therefore fall outside of the control of the legislation. This is an important issue and one that the project needs to consider closely.

Year	1998	1999	2000	2001	2002	2003	Total

Requests	Groundwater	294	830	436	307	316	120	2303
	Surface Water	75	167	134	122	108	52	658
	Sub- Total	369	997	570	429	424	172	2961
Licences	Groundwater	118	254	203	193	190	88	1046
	Surface Water	12	47	48	111	85	29	332
	Sub- total	130	301	251	304	275	117	1378

As an instrument of national and regional water resources policy, Water Resources Master Plans – PDRH – have been created for each river basin. The river basins encompass the major river systems and their tributaries from the headwaters to the outlet at the coast. Thus these master plans cover a wide range of physiographic and demographic conditions and the areas, which are of interest for the project, occupy only a very small part of the total basin area within which they are located. The first part of each plan is a diagnosis of the current situation covering:

- water resources availability,
- the analysis of population growth,
- the evolution of productive activities and the standards of land use.

Further an assessment is made of the balance between water resource availability and future demand in terms of both quantity and quality. Potential conflicts are identified in the determination of this balance. The plan also states the goals for rational use of water and for the improvement of the quality of the available water resources and covers the actions to be taken, the programmes to be developed and the projects to be implemented. To fulfil the development goals, priorities for licensed use of water resources and proposals for protection of the water resources are also included.

From the Pernambuco State Water Resources Master Plan - PERH (1997) it is possible to gather information from the well inventory for the cities Pesqueira and Poção, with the following elements:

- owner,
- location,
- date of construction and institution,
- depth, water level,
- flow rate,
- chemical analysis, and
- water use.

A further well inventory has been performed for the Pernambuco state by the Brazilian Geological Survey (CPRM), but production of the inventory is still in progress and has not yet been published.

The project areas; Rosário, Campo Alegre and Mutuca are located in the river basins Ipanema, Ipojuca and Capibaribe. The master plans for these basins present information on:

- the existing hydraulic structures;
- the geology and pedology;
- the land classification for irrigation;
- vegetation and land use;
- hydrological classification;

- climate: wind, temperature, evaporation;
- surface water analysis;
- precipitation;
- projected dams;
- agricultural development;
- operation of reservoirs: flood control, water supply;
- groundwater; water quality;
- socio- economy: population, income, etc.;
- water demands.

An evaluation of the reservoirs and dams in the area was supported by the information on the PERH and by the monitoring and planning team of the Secretariat of Science, Technology and Environment of Pernambuco State - SECTMA, and covers are range of data including area, capacity, location, river and other characteristics. Data are also available from Pão de Açúcar dam (located in the Ipojuca river basin, on the upstream segment of the Campo Alegre project area).

Other information such as the historical series of rainfall in the region and surrounding regions has been obtained from the database of the Secretariat for Water Resources – SRH.

4 The Project Areas

4.1 Physical Setting

The project areas are all located in the municipality of Pesqueira in the transition zone between `agreste´ and ´sertão', in the semi-arid region. The project areas are located in three different watersheds: Mutuca valley is located in the Capibaribe river basin (UP2), Mimoso valley is located in the Ipanema river basin (UP7), and Campo Alegre is located in the Ipojuca river basin (UP3). The three basins are highlighted in Figure 2.1. Figures 4.1 to 4.3 show the setting of the Pesqueira Municipality and the three Project study areas.

4.1.1 Climate and Hydrology

The climate in all three project areas is similar to that monitored at the Pesqueira Meteorological Station, located approximately 15 to 20 km from the project areas. In Table 1, the main climate variables compiled from a 30 year period are presented. Rainfall is unevenly distributed, with 75% of the annual precipitation rates falling in 6 months (from January through to July). The dry season – from September through January – accounts for about 47% of the annual evaporation. The temperature distribution is typical of a semiarid zone, with high temperatures and little variation. The annual maximum temperature is about 29°C and the minimum is just less than 18°C.

The annual average relative humidity is 75%, with the highest values after the rainy period (May - July) and the lowest values in the dry period (September - November). Insolation reaches a value close to 2400 hours per year, which means a daily solar incidence of about 5 hours uniformly distributed throughout the year. About 19% of the annual insolation occurs from May to July. Winds are predominantly south-western with moderate wind velocities less than 4.4 m/s: the greatest wind speeds occur in the dry period.

Table 1.Pesqueira station main climate parameters (30 year period).

Parameters	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total/ Average
PREC (mm)	51	91	86	121	101	81	72	37	23	19	18	29	730
TEMP(oC)	25	24	24	23	22	21	20	20	22	23	24	24	23
ETP(mm)	164	147	153	133	122	106	110	125	140	159	160	163	1683

(PREC= average rainfall; TEMP= average temperature; ETP= potential evapotranspiration) (Irrigation project of 'Nossa Senhora do Rosario' farm (CISAGRO, 1990)).

Figure 4.4 shows the historical rainfall measured at the climate station at Pesqueira for the period from 1910 to 2001. The average annual rainfall for the period is 677 mm with a range of annual totals from as low as 153 mm (1941) to as high as 1299 mm (1924). A linear trend line indicates a declining trend over the considered period indicating a rate of decline of about 1 mm/year. The figure also shows a five-year running mean of annual rainfall. This indicates a clear cyclic pattern in annual total with a return period of about 11 years, although this cannot always be detected with certainty. Severe drought periods are evident for the periods from 1938 to 1943, the early 1970's, 1980's and 1990's.

Figure 4.5 shows the deviation of annual rainfall from the long-term average. It clearly indicates that below average rainfall can occur over a significant number of years.

Rainfall occurs irregularly during the rainy season as is evident from Figure 4.6, which shows monthly rainfall for the period from 1980 to 2000. Extreme events are evident with monthly rainfall totals in

excess of 400 mm. The rainfall event in January 2004 indicated the extreme nature of rainfall. A total rainfall in excess of 400 mm occurred over a period of only a few days.

The rivers in the project areas are ephemeral with flow only occurring during the rainy season after significant rainfall events. Control structures on the streams, generally in the form of cross-dams, limit the stream flow and allow for containment of water behind the dams. Surface water is retained in the streams until about October, although this obviously depends on the rainfall over the preceding rainy period. At some stage no flow occurs in the streams and the surface water is in fact an extension of groundwater levels in the alluvial deposits underlying the streams.

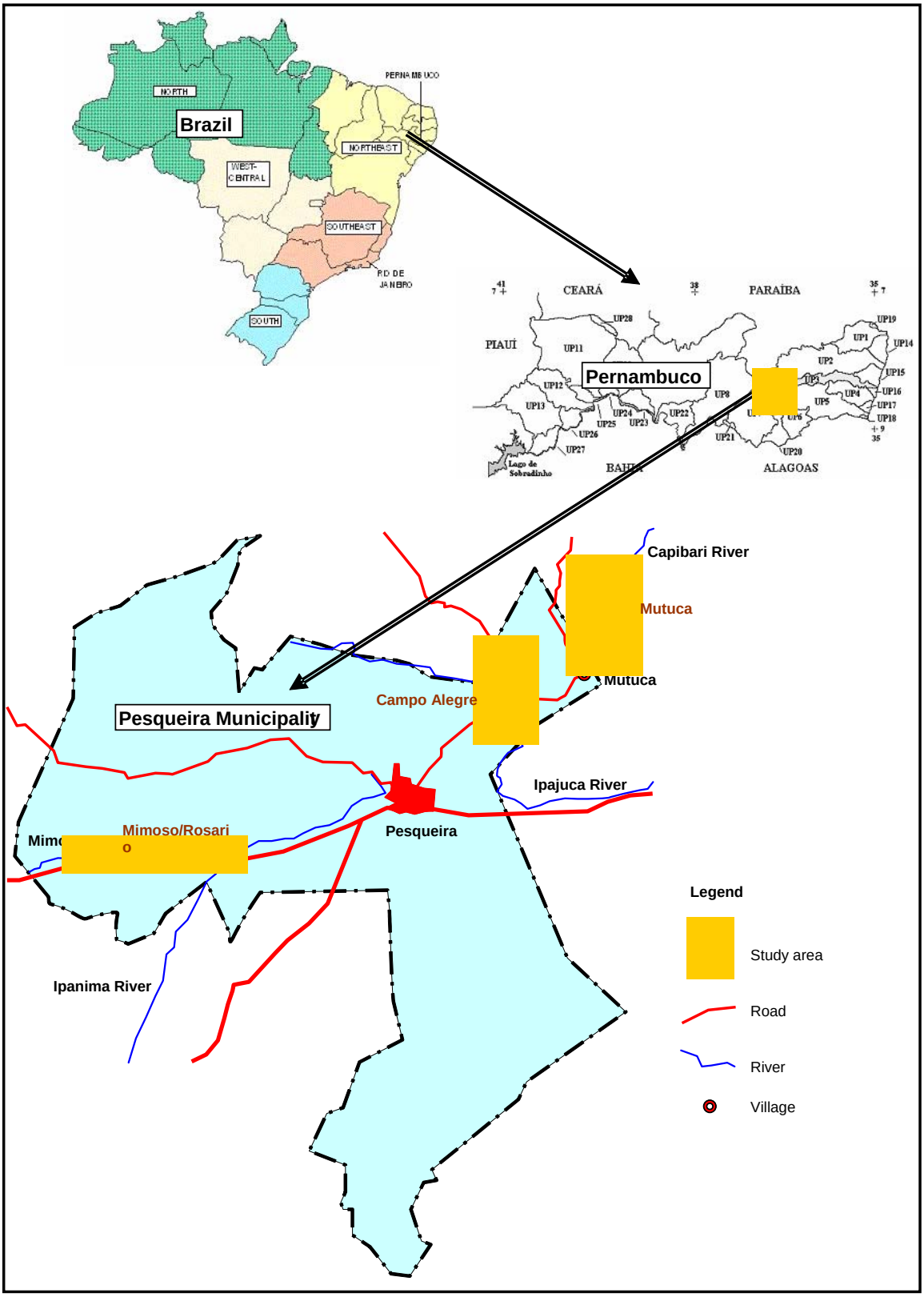
4.1.2 Geomorphology and Soils

4.1.3 Geology and Hydrogeology

Mimoso valley

Characterisation of this valley is well advanced through the long term development of a communal irrigation project located at 'Nossa Senhora do Rosario' farm, in Mimoso valley. The farm lies in a gently sloping watershed. The average altitude is 630m above sea level, with an average natural slope of 0.3% in the line of the valley. The flat topography controls the natural drainage of the system. The watershed stream network comprises the 'Mimoso', 'Ipaneminha' and 'Jatoba' rivulets. The 'Mimoso' is the main rivulet of the watershed, being connected to the aquifer along its length. These rivulets are ephemeral, flooding the area during wet rainy seasons, and becoming dry for several months in the dry season. The use of the surface water resources, which are regulated by means of small dams, has been restricted to domestic supply to the nearby cities. Thus, the groundwater is the only suitable source of water for irrigation.

Figure 4.1: Location of Project Area



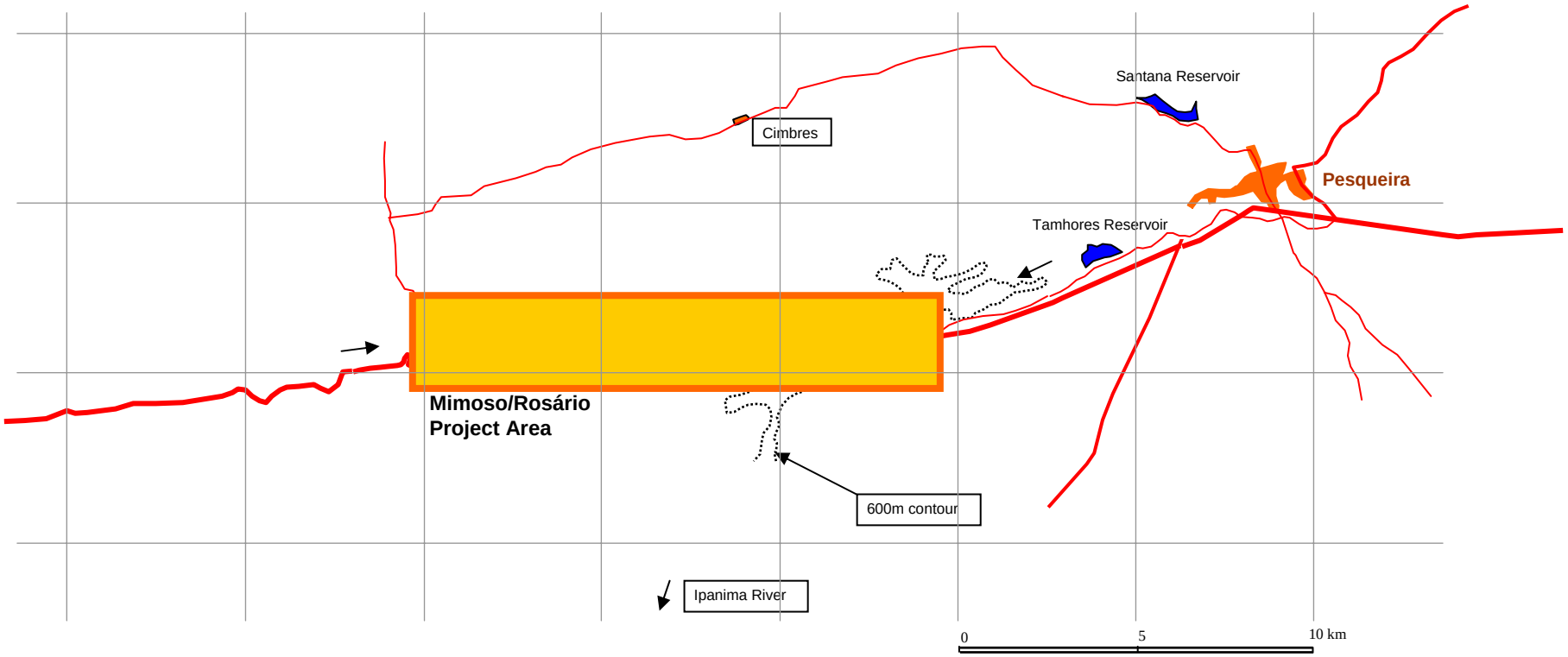


Figure 4.2: Mimoso/Rosario Project Area

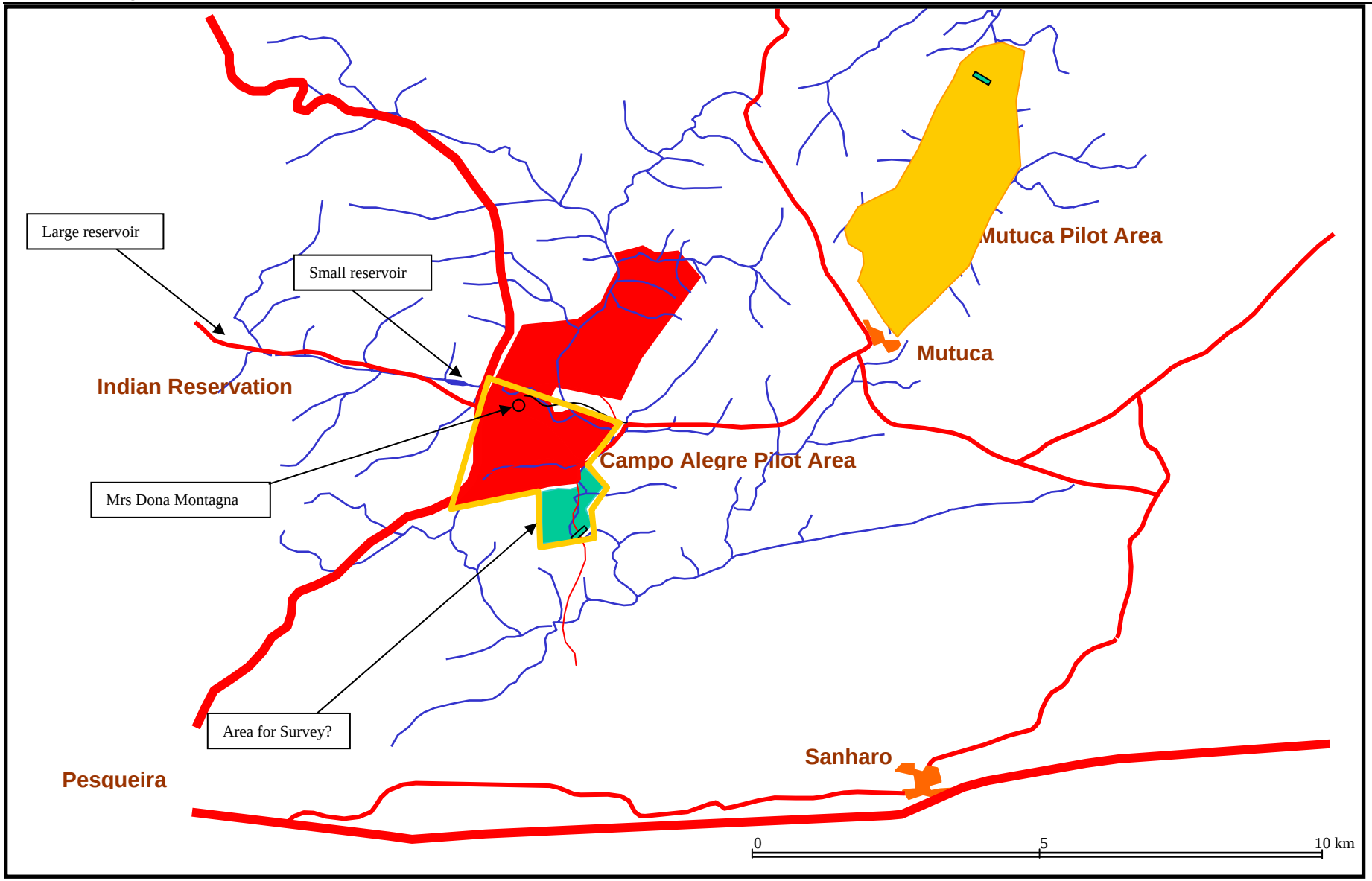


Figure 4.3: Campo Alegre and Mutuca Study Areas

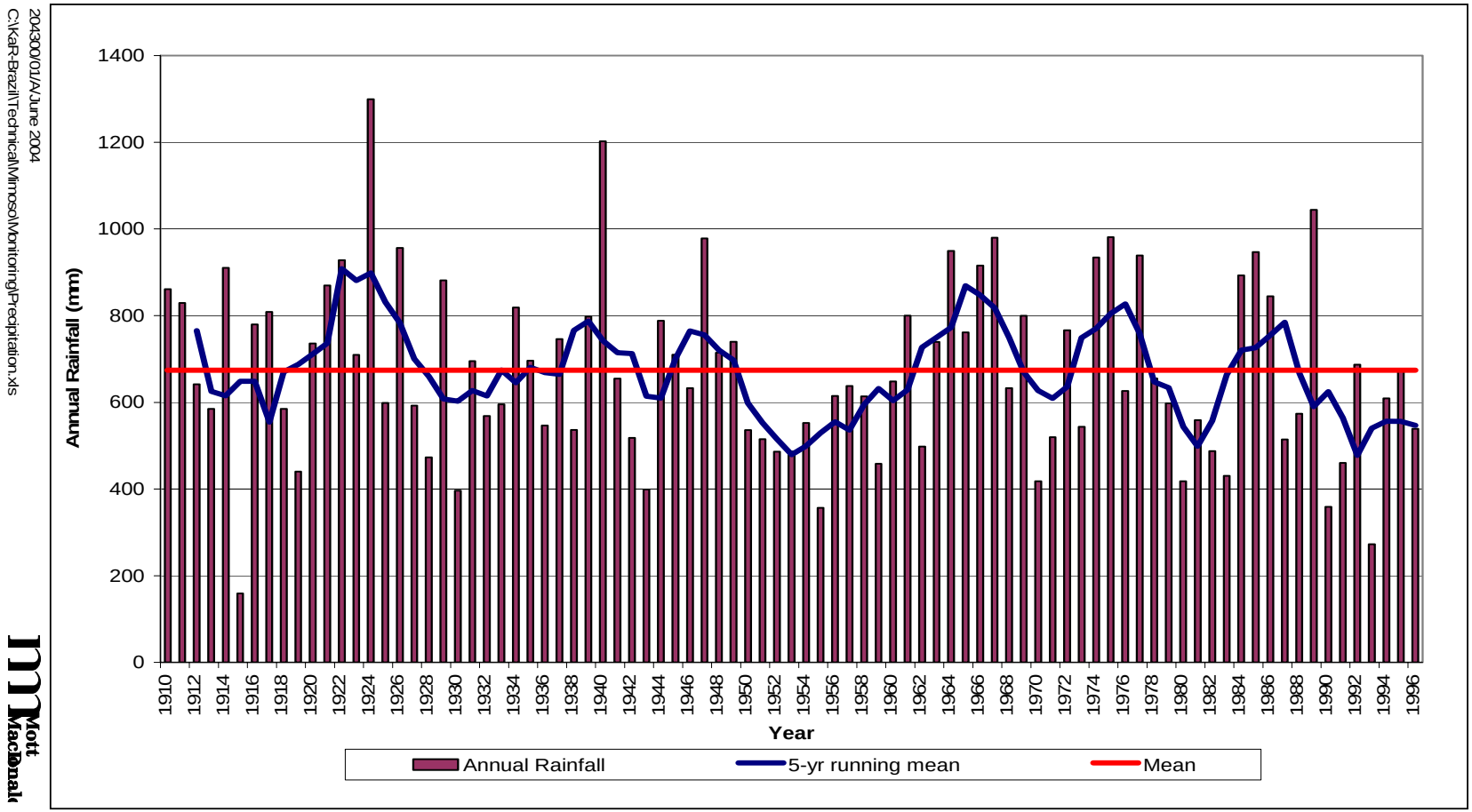


Figure 4.4: Annual Rainfall at Pesqueira

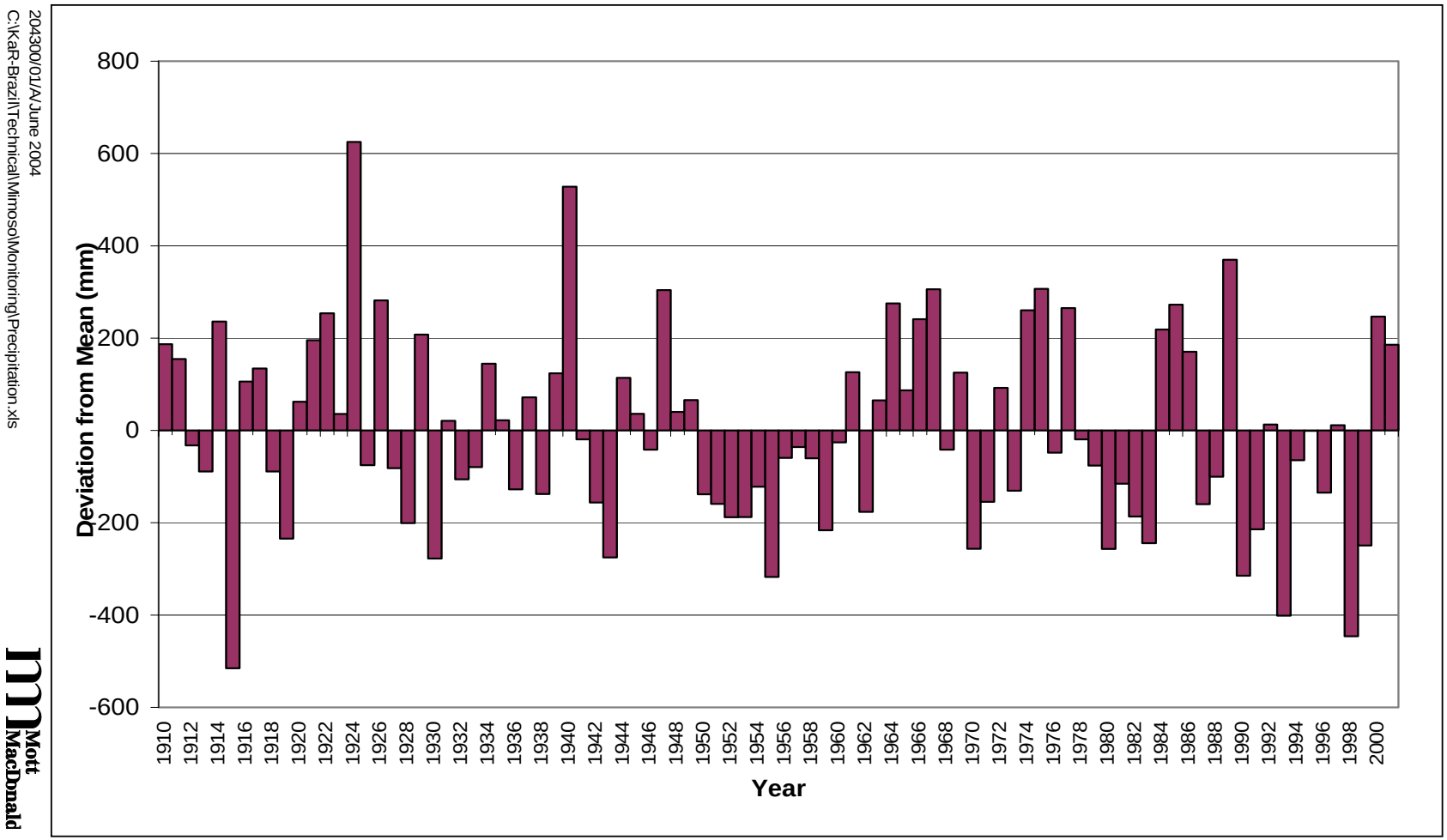


Figure 4.6: Deviation from Long-term Annual Rainfall

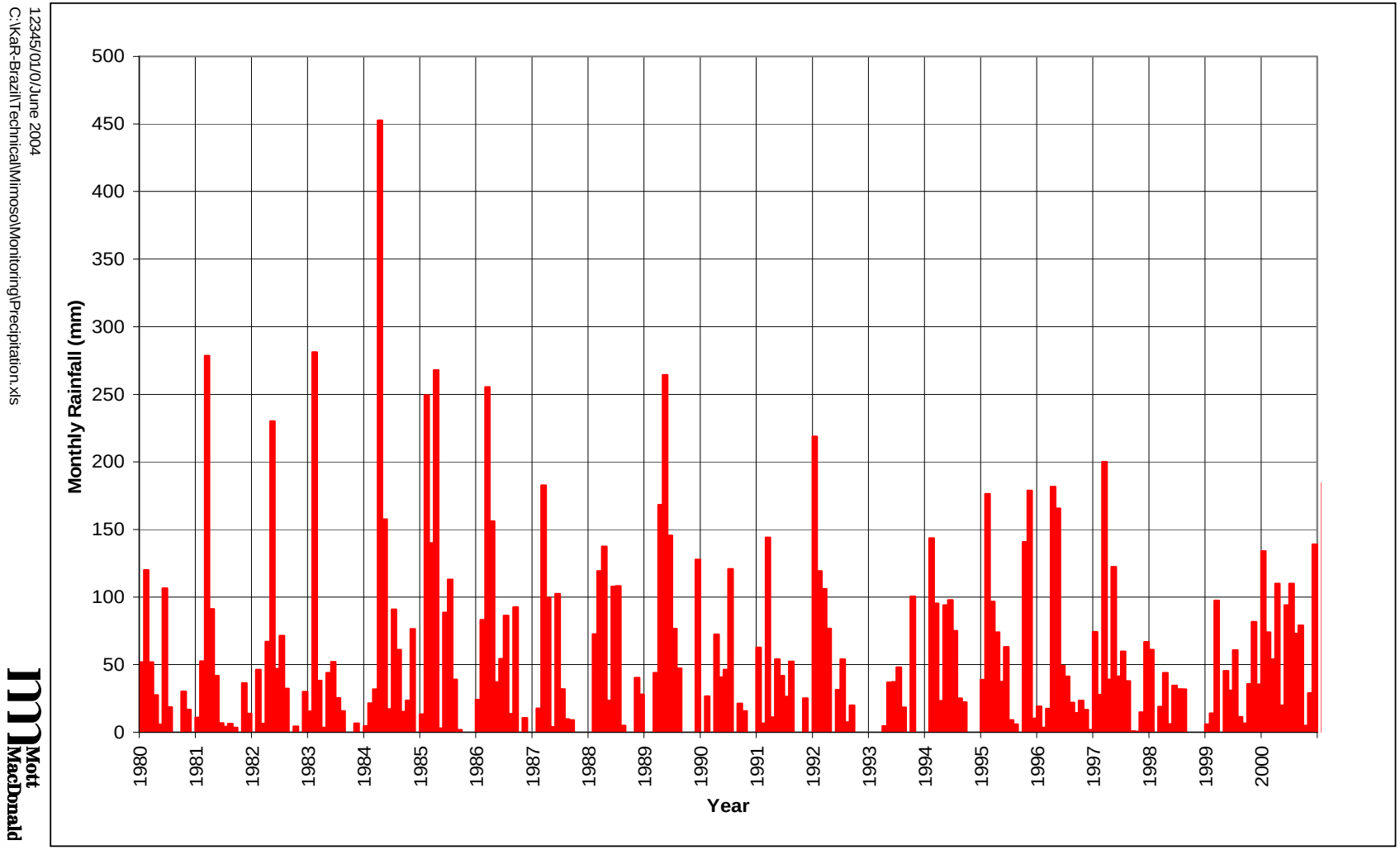


Figure 4.7: Monthly Rainfall for 1980-2000

The underlying alluvial aquifer is relatively shallow, about 10m deep, 300m wide and 15 km long. The aquifer is a fine to medium sand deposit, with some clay lenses. The water table in the area is relatively shallow, with depths ranging from 2 to 5m. Previous hydrological studies have indicated values between 160,000 and 300,000m^3 as the annual exploitable water resource in the aquifer (CONESP, 1988; Montenegro, 1997). The average hydraulic conductivity has been found to be about 5-6m/day and the specific yield is 6% (CONESP, 1988). The relatively high hydraulic conductivity has allowed aquifer exploitation by open wells, connected to lateral multilevel drain tubes (radial collectors). This kind of well has been shown to be suitable for exploitation of very shallow aquifers, producing good performance at relatively low rates of water table drawdown. The original irrigation project for the area included the installation of four wells, 10m deep and with 3m diameter, although currently many other open wells of larger diameter have been built by the farmers. Directives for exploitation of the aquifer using the wells have been issued based on preliminary hydraulic tests.

Pedological investigations have been carried out in the 'Nossa Senhora do Rosario' farm area in order to adequately identify the soils with potential to be irrigated, mainly from the point of view of drainage and water transmission . The total area of the survey constitutes 173.6ha. The soils in the study area are classified into five groups: alluvial, yellow red podzol, regosol, litholic and gleyed.

Table 2. Soil groups and units in 'Nossa Senhora do Rosario' farm.

SOIL GROUP	SOIL UNIT	AREA (ha)
Alluvial	Ae	38.2
Regosolic (Entisol)	REe1 REe2	18.8 46.6
Red yellow podzolic	PE1	29.8
Litholic	Re1	26.9
Gleyed	HI	13.3

Additionally, a land classification study for irrigation has been completed. The land characteristics in the area have been described according to U.S. Bureau of Reclamation (US Soil Conservation Service) criteria, and account for use, potential yield, depth, topography, drainage conditions, water availability, ploughability and development and production costs.

The total area of 'Nossa Senhora do Rosario' farm is 606.24 ha, with only about 100ha potentially suitable for irrigation. The irrigation project's design indicates that of this area, only 32ha could be effectively irrigated, given the limited water resources and suitability for agricultural practices. The total area of the project has been divided into four sectors, each being supplied by one of the four wells. The four sectors are divided into a total of 24 plots, of about 1ha each, making up the portion of irrigated land in the farm. The main crops cultivated in the area are tomatoes, cabbages, beetroots, carrots, peppers and green peppers. The directives adopted by the irrigation project dictate that cultivation begins in September with harvesting in December for most crops. The crops are irrigated daily. Although a subsurface drainage network has been designed for the irrigated area, to date it has not been built. The farmers at 'Nossa Senhora do Rosario' farm are organised into a co- operative group to facilitate technical assistance from the Government.

For characterisation of the salinity distributions in the alluvial aquifer, 80 piezometers have been installed on the farm area (Mackay e Montenegro, 1996). These piezometers have depths ranging from 5 to 8 metres and separation distances from 5 to 2500m. Water samples have been monthly extracted from piezometers since 1995, when they had been installed, allowing the analysis from the water table depth and electrical conductivity of the water in the saturated porous media (ECw).

The upstream area is characterised by sandy soils with little clay, but the clays increase significantly downstream. The upstream area has good drainage caused by natural soil units while downstream the soil drainage is more restricted. The link between geology and pedology is apparent in this simple

observation (Montenegro et al, 2001). According to the available soil salinity the salinity is also strongly correlated to the geology but is also partly linked to the inputs of water and salts from the stream tributaries that join the main stream.

Mutuca

Mutuca is a district of Pesqueira municipality. The area contains 10 underground dams, built by the Pernambuco State Government in 1999, along the alluvial valley of the Mimoso rivulet (in the Capibaribe river basin). The valley is located in the border between Jatauba and Belo Jardim municipality and is covered by a large percentage of planosols. Although the valley sediments are relatively deep (from 4.0 to 10m), impediment layers restrict direct recharge. Groundwater storage is mainly controlled by the underground dams.

Besides monitoring along the valley and investigations on recharge mechanisms (Blackburn et al., 2002), a pilot area has been installed with micro-sprinkler irrigation, just upstream from one of the dams. Montenegro et al. (2003) detail the hydrogeological behaviour of this unit, and the irrigation impact on water quality.

According to Montenegro et al. (2003), loam and sandy loam soils are dominant at surface. Infiltration tests have been conducted across the area, producing an averaged infiltration rate of 9 cm/day. This low infiltration characteristics require careful irrigation management and low irrigation water depths. Soil electrical conductivity monitoring during the dry season in 2003 indicated that around 35% of the total samples analysed exhibited values greater than 4 dS/m, requiring salt management.

Campo Alegre

Campo Alegre is the least well characterised of the three study areas. It is physically distinctly different to both of the other two study areas in that the alluvial sediments are constrained in a much narrower valley. The Campo Alegre area presents undulating relief and valleys with relatively steep sides and occurrence of narrow alluvium bands. The relief has been moulded by morphogenetic forces that created the geomorphological unit of Borborema Formation. The rocks that constitute the original material of the majority of soils are acid plutonic, being mainly found Saprolite of biotite-granite. Predominantly, sandy sediments of alluvial-colluvial nature occur, attributed to the Holocene period, in narrow plain land bands on the edges of the Ipojuca River. All the irrigation area has already been deforested. Only isolated points of the remaining typical vegetation of Caatinga can be found. Groundwater is highly saline in the dry season, limiting crop production and irrigation.

The study area is located in the part of the catchment downstream from the eastern boundary of the Xukurú reservation. Near the headwaters of the catchment on reservation land is the Pão de Açucar reservoir. This is the largest reservoir in the region and has a major controlling influence on the transmission and retention of waters in the river system.

Historically, waters were released along the river from the Pão de Açucar reservoir, and these certainly were exploited for irrigation. Since the start of the drought in 1988, the flows on the river have been significantly reduced and groundwater exploitation from the alluvial deposits was expanded to compensate the reduction in surface flows. Most of the wells excavated in the alluvium were destroyed during the recent heavy floods. Several dams/weirs are located along the river corridor, which impede surface and subsurface water flow. The impounded waters upstream of these structures provide surface water for irrigation during the rainy season and groundwater exploitation as the surface waters recede in the dry season. The alluvium cannot sustain groundwater supplies indefinitely during drought periods and the water becomes strongly salinised.

Streams contributing to the river have been dammed to construct small water supply reservoirs in some parts of the catchment. Rainfed agriculture is extensively practiced and significant areas of

Palma are being cultivated for cattle fodder. Rainwater harvesting on these agricultural areas is restricted. Soils in the area are typically thin, overlying regolith, and these have limited moisture holding capacity. Livestock farming is a major component of the land use of the area. Some rainwater is trapped behind earth embankments for livestock watering.

4.2 Socio-Economic Setting

4.2.1 Demographic Data

The municipality of Pesqueira, the site of the KaR Project, is located in the Agreste sub-region of the Pernambuco state and occupies an area of 1 032 km^2. Pesqueira has a population (based on which census data?) of 57 602 inhabitants, 27 763 of whom are men and 29 839 women. The urban population is comprised of 40 892 inhabitants and the rural population accounts for 16 710 inhabitants. It can be noted that the urban population is much higher than the rural and this is the case of most municipalities throughout Brazil. It reflects the out migration of people from the rural sphere. The demographic density in Pesqueira is 55.84 inhabitants per km^2.

4.2.2 Historical Context

Although the municipality shares most of the characteristics of medium sized cities in the Agreste, it has some unique characteristics. Pesqueira was once a very important cultural centre in the region. Many of the elite members of society from surrounding cities used to send their children to boarding school in Pesqueira. In demographic terms, besides the presence of the afro-Brazilian population, which forms the majority in the Northeast, the area is the place of origin of the Xukurú Indians. Pesqueira also had two industries, the most important of which was the Peixe, an industry devoted to the production of tomato sauce and fruit jelly. Besides actually processing the vegetables and fruits, Peixe owned large amounts of land where the crops were cultivated. The Peixe industry played a major role in the economy of the municipality and the region as a whole as it employed a large number of people from both urban and rural areas. The Peixe industry was known as Carlos Brito Indústria Alimentícia S.A. and was owned by a local elite family. The industry was exposed to bankruptcy at the beginning of the 1990´s and the municipality was severely affected. In order to pay for the debts owed to the state government, the Peixe industry was obliged to forfeit its land in 1992. In 1996 the government decided to transform the area once owned by Peixe in *assentamentos* so that the former workers, who were landless, would be able to receive indemnities in the form of land to cultivate.

4.2.3 Profile of the Municipality

(i) Municipal Government

The political milieu in Pesqueira is typical of that found in other small sized cities in the Northeast. Political and economic power is found in the hands of the elite, which is composed of traditional families. At the last election, however, the elected mayor did not belong to such as group. He was a soil scientist who came to Pesqueira several years ago to work for the Rosa Industry. After the industry was closed, he decided to remain and then became involved with politics. Although he is not from a local elite family, he belongs to the economic elite. He belongs to PFL – The Liberal Front Party - the right-wing political party and is running for re-election in 2004. Local opinion indicates that he is not considered as a charismatic person and that it is therefore felt surprising that he was elected. He is considered very conservative and the population has mixed feelings about him. At this moment, there is a great deal of uncertainty as to whether he will be re-elected or not.

The Secretariats have a detailed action plan and as new elections are approaching, they are closing their Activities Reports. The Secretariats seem to be well integrated and instead of having separate actions, they try to work together as much as possible. The Hunger Zero Programme, for instance, is found under the joint responsibility of the Agriculture and Social Actions Secretariats. The Bolsa Escola, which aims at keeping the children in school by providing some financial help to the families, is found under the responsibility of the Secretariats of Education and Social Action. Despite working together, each of the Secretariats also has its own programme of activities. In order to understand the impact of the Municipal Government, it is important, to present some information about each of the main Secretariats which are Agriculture, Health, Education and Social Action.

(ii) The Secretariat of Agriculture, Environment, Food Supply and Water Resources

This Secretariat covers a broad scope as it encompasses Agriculture, Environment, Food Supply and Water Resources. It works closely with farmers on a series of issues, ranging from training workshops on cooperative work to animal raising and food. Furthermore, it supports, implements and monitors governmental programmes (federal and state) in several areas such as, PRONAF – The National Program to support small-scale family agriculture and PRORURAL – which provides credit and improves infrastructure. Through the support from these programmes, the Secretariat was able to implement several actions to improve the water supply in rural areas. It constructed nine tube wells, two dug wells, 10 small dams and installed nine desalination plants.

The Secretariat works closely with the rural population, especially those who live in small communities and supports as well as assists Associations of Small Food Producers. Many governmental programmes reach the beneficiary population through the local Associations. The Associations have to apply for the programmes and this is done with the guidance of the Secretariat. As a result, most of the Small Farmers Associations have close ties with the Secretariat.

(iii) The Secretariat of Education

Education is an area, which has been receiving much attention. There are 116 schools in the municipality. These schools are distributed as follows: eight schools are administered by the state government, 97 by the municipal government, one by the Federal Government and 10 by the private sector. The municipal government schools are all at the elementary level and the majority of them are found in rural areas (74 out of 97) with the remaining 23 located in the urban area. The Secretariat has a co-ordinating role to deal specifically with rural education and it offers periodic training to teachers. Most of the rural teachers are from the area where they teach, which is very beneficial as they are familiar with the problems affecting the population.

The eight schools administered by the state government are mostly found in the Pesqueira urban area, however some are found in large districts such as Mutuca and Salobro. These schools offer higher training, at the middle and high school levels. The students, who live in rural areas and who reach middle and high school levels, travel to Pesqueira or to the nearest place where the training is offered and to attend classes. Transportation is free of charge and is provided by the municipal government. There is only one school administered by the Federal Government, which offers technical education. This school is located in Pesqueira and although it offers free education, it is an elite school as the level of the professors is high and the entrance examination is very competitive. Beyond that, there are 26 schools found in the Xukuru indigenous reserve, 24 of those offer elementary education whereas two are at the high school level. Besides the 10 private schools, there is a college administered by the state government, i.e. the Universidade de Pernambuco, which offers only one undergraduate degree in Education. Despite the fact that this College benefits the population seeking the training offered, the students have to pay for tuition and those not interested on pursuing a degree in Education, have to go

to nearby cities such as Belo Jardim and Arcoverde to work on a College degree. Access to education at that level is, however, restricted to a few as the majority of the population cannot afford it.

Table *** provides some relevant data about the educational profile of the population of the municipality as a whole.

Level	**Number of Students**
Pre-School	2 272
Elementary	6 518
High/Secondary	171
Adult Literacy	3 664
Handicapped	26
Total	**12 651**

Source: 2003 Report, Secretariat of Education

It can be noticed that the largest number of students is found at the Elementary and Adult Literacy levels. This means that the illiterate adult population is having access to basic education and that most of the school students are stopping attending school after completing Elementary School.

(iv) The Secretariat of Health

The municipality of Pesqueira can be considered poor in regards to health services. In terms of infrastructure, Pesqueira has one hospital, 11 health centres, four of which are found in the urban area and seven in the rural sphere, six PSF (Family Health Programme) and three indigenous PSF (Xukuru), one mobile dental unit and 13 dental offices. Despite the limitations in terms of infrastructure, there have been achievements concerning the services offered. Two of the most important achievements have been seen through the services available through PSF and PACS (communitarian health agents). Both of these services reach out to the population and focus their attention on prevention rather than treatment. The team, which forms the PSF, includes nurses, doctors, dentists and health agents.

The health agents work at the community level and maintain a record on the health conditions of all community members. There is a total of 101 health agents in the municipality, 53 of them work in the PSF team and the remaining 48 work only at the community level. They are key persons in the local health team and provide the main link between the community and the services available. The health agents are selected through an examination offered by the Coordination at the state level. After they are selected, they attend a series of training workshops. The areas in which they have received training include immunization, diarrhoea related disorders, DST/HIV, Hunger Zero and nutrition, water resources management, and prevention of child abuse. PACS covers 100% of the population.

The nine units of PSF cover 58% of the population. Of the three units found in the rural areas, two are located in the Project area - one in Mimoso and one is Mutuca. The population that benefits from PSF receive periodical care from doctors and permanent attention from health agents. Besides that, the ill receive free medication. PSF receive financial support from the municipal, state and federal

governments. The federal government funds 50% of the programme, while the municipal government funds the remaining 50%. The state government provides all of the medication and training workshops.

(v) The Secretariat of Social Action

This Secretariat focuses on a broad range of programmes and many of the actions it develops overlap with those of other Secretariats. Thus, there is a lot of work done in partnership with others. The Social Action Secretariat works with different age groups. It provides assistance to the elderly, the homeless, the handicapped poor population, and young children (up to six years of age). Furthermore, it supports children between 7 and 16 years of age living under severe poverty conditions to better integrate in society and to remain at school. It is responsible for the implementation of the Federal Government Programme – PETI – The Child´s labour eradication programme, and BCC – Brazilian citizen's children. Besides implementing and monitoring governmental programmes, the Secretariat also seeks to develop networks with NGOs in several activities.

(vi) The Xukurú Indigenous Population

The Xukurú is formed by a population of approximately nine thousand indigenous people who live in twenty-four communities in a reserve with an area of 27 555 ha stretching westward and northward from Pesqueira town. The Xukurú are neighbours both to the Rosário *assentamento* to the south and to the *assentamento* of Campo Alegre to the east. One of the most important sources of income of many Xukurú is the production of crops, which are sold in the town market. Despite their integration within the larger society, the Xukurú have been able to maintain their own traditions with regards to their social organisation and beliefs. The Reserve has several schools, and the teachers as well as health workers are all from the Reserve.

The Reserve was recognised by the Federal Government in 1998 and has received attention from FUNAI – The National Indian Foundation. The tensions between the Xukurú and the Pesqueira population are not only due to the limited access to the Cimbres Sanctuary, but also to the fact that the Reserve occupies the most fertile land in the area, where the most important surface water reservoirs are also found. The *Pão de Açucar* reservoir is the largest of these reservoirs with a capacity of 34 million m^3 (acc. COMPESA). The reservoir dam was built in 1986 with the goal of providing water to the city of Pesqueira. However, the reservoir has not been fully utilised as main water supply source to Pesqueira in recent years, in part due to the lack of a pipeline connection to the town. Obtaining a downstream water supply from the reservoir was achieved via controlled downstream releases through the dam, into the Ipojuca River, with a much smaller secondary barrage located further downstream, allowing water to pool for the irrigation purposes of the Xukurú farmers. The outlet control from this reservoir to downstream users such as those in Campo Alegre, is thought to rest with the Xukurú, although the exact nature of control over the reservoirs is uncertain.

As a result of the characteristics of the land occupied by the Xukurú, their relationship with the large landholders who owned the land prior to the legalisation of the Reserve has been very difficult and has been characterised by violence. There are also some conflicts between the local political and economic elite and the Xukurú. The neighbouring communities are very suspicious of the Xukurú. The small landholders fear that the Xukurú are not willing to collaborate with the non-indigenous population in any respects, including access to the water reservoirs found in the Xukurú area. The Campo Alegre *assentamento*, one of the study areas, is located to the east of the Xukurú Reserve.

4.2.4 Rural livelihoods: Agriculture and other Economic Activity

The most important economic activities in Pesqueira are agriculture, cattle breeding and poultry. However, the local economy is not only restricted to these activities. Beans, corn, manioc, tomato and guava are the most important crops produced. Poultry has become important in recent years due to financial incentives received by small landowners to engage in that activity. The municipality also has small-scale factories of jelly, dairy products, and, to a larger extent, furniture. The wood utilized in the manufacturing of furniture comes from the northern state of Pará. Another very important source of income is lace making and embroidery, activities which have been predominantly female, but which are increasingly being performed by men due to high unemployment rates. Women from both rural and urban areas complement their household income through the production of lace artefacts and sell their products in the local market. In times of severe drought, this activity becomes of great importance. Although the profit made from lace making is not high, the fact that it is stable makes this activity very important. In this context, the women play a very important role in the society. In contrast with most rural areas throughout the Northeast, where women do not have any skills and are thus dependent on their husbands, the women in Pesqueira benefit from lace making. This can be seen as a form of empowerment for them as women become respected for providing some income to support the family. The importance of lace making is higher in areas where the work opportunities are fewer.

Up until recent times, tourism could also be considered as another important economic activity in the municipality. Oral historical accounts of a Sanctuary where the Virgin Mary appeared to three local children many years ago - The Cimbres Sanctuary, attracted many religious tourists to the municipality. This activity has decreased in importance since 1998, when the area, where the Sancutary is located, became part of the Xukurú Indian Reserve. The Xukurú have restricted the flow of tourists to the area and this has caused some tension between the Pesqueira population, the municipal government and the Xukurú Indians as the presence of tourists contributed, to a large extent, to the municipality's economy.

4.2.5 Social Stratification and Organisation in the Project Areas

(i) Rosário

The *assentamento* of Rosário is located in the Mimoso Valley, a very rich area in terms of the availability and quality of water. The Mimoso Valley is one of the few areas where groundwater is commercially exploited, especially during drought periods. The groundwater is not only of good quality but is available throughout the drought period. Rosário covers an area of 592.7 ha and this land was divided into sixty *parcelas* i.e. plots. Fourteen of these plots, i.e. 25%, are found in the ownership of women. The majority of the dwelling houses on this *assentamento* are grouped together in a village which, like other villages, has a school and a church. The State Institution responsible for the initial organisation of the *assentamento* was FUNTEPE – The Pernambuco Land Fund. The sizes of the plots vary slightly and the average size is around five to seven hectares.

Part of this land is referred to as *várzea (*flood-plain), and is the most appropriate land for irrigation. Each of the *assentados* has one hectare of this type of land. They also hold a larger area, which is considered by the them as drought-prone, as it is not suited for irrigation The *assentamento* has benefited from several investments, in the form of grants, for the construction of wells and irrigation equipment, a dairy factory (which never worked), and the purchase of a community tractor (which is managed by the local Association).

The State Government also provided funds to the community electrification. Even though the beneficiary families do not have title to the land they occupy, they were encouraged to apply for loans

to invest in the infrastructure of their plots and in the purchase of animals. Most of those who identified themselves in the socio-economic survey as *assentados* and *parceleiros*, i.e. those who do have access to land, mentioned that they received loans and had problems repaying them. Due to the availability of the funds either through loans or grants, Rosário benefited and has a high number of wells and a high number of irrigated plots.

Despite the high investments and attention from the Government, Rosário has had several problems since its beginning. In 1992, many of those who occupied the area were former Peixe employees. However, when the State Government decided to turn the area into an *assentamento* in 1996, many of them had left and had even sold the plots without documentation. Land continues being sold and the price is given according to the plot's infrastructure (fences, wells, houses, etc.). A plot of land in Rosário costs from R$7.000 to R$10.000. This situation causes serious problems to the area and its social organization as the families who sell their plots and migrate to other areas, tend to return to the community and form the masses of *"moradores"*, i.e. the landless. Besides holding return migrants, Rosário is also the home of the settlers´ offspring, who usually stay there after marrying. According to a FUNTEPE employee, Rosário has become a *favela rural*, i.e. rural slum and although it was planned to hold sixty-one families, it now has a population of approximately one hundred families.

Beyond this problem, Rosário residents are not united and there are several community factions. Actually the population has never been united even at the initial stages of the *Assentamento*. At that time, people were encouraged to form an Association. According to the Rosário population, the first elected Board had problems as the dwellers mistrusted the Board members and accused them of robbery. The next elected Board has been in power for ten years. Furthermore, although the current President of the Association is an *assentado*, he does not live in the community and, as a result, does not participate in community life. He is not well liked and is one of the financially better off individuals in the community. Membership of the Association is decreasing and among the members only very few pay the monthly fee, which is R$2.00. Due to the inefficient role of the Association in raising the population's consciousness about their rights and the importance of mobilising politically, and in bringing the population together to improve the living conditions at the *assentamento*, the majority of Rosário dwellers are apathetic and are not worried about collective projects but only think about their individual needs. The behaviour of the community members reflects the top-down nature of government assistance and the lack of opportunity these people have had to be heard. They were never consulted in regards to which projects should be implemented in the community neither did they mobilise to get them.

As in most communities, the poorest of the poor, who are usually landless, are very difficult to approach. Those people have to work for others and are usually not available to participate in meetings. This poses severe limitations for them to be integrated in community life and in projects that would help them improve their quality of life. In many cases, the most destitute population is excluded from benefits because they are not "visible", that is, those in charge of the benefits do not know who they are or where to find them.

An interesting factor about life and the social dynamics between community members and resources is that despite all of the problems with community rivalries, there is no dispute in regards to water and this resource is shared with those in need whenever it is necessary. This is the case only in regards to drinking water not water for irrigation or livestock. It is very understandable why only drinking water is shared with those in need as the energy used to pump water from the wells is paid for and it would not be fair to pay for water to be utilised by others in irrigation or for animal consumption, which are income generating activities

Next to Rosário there is a group of approximately thirty landless families. They belong to MST – The Landless Social Movement and have settled on public land along the road for about two years to wait for the government's decision to dispossess a farm located in the municipality in order for them to occupy. However, the government's decision was against the MST interests and these squatters have

been requested to leave the public land which they occupy. Although they have been told to leave, they are still there because they have no place to go. Although no data was collected from them as they seem to be very suspicious of strangers, there does not seem to be any hostility between them and the Rosário dwellers and there is a case of a Rosário *assentada* woman who found a partner among the MST settlers.

(ii) Campo Alegre

Campo Alegre occupies an area of 863 ha and was divided in eighty-five plots of land. It was initially planned to be occupied by eighty-five families. The plots vary slightly in size and the average size is seven hectares. The area is cut by the Ipojuca River and the *assentamento* is composed by clusters of houses or *agrovilas: Esmero, Sete Barracas.*

Although in the past (1989), there was an Irrigation School in the *agrovila of Esmero*, there is not much irrigation in Campo Alegre as it lacks the necessary water sources. According to the local population, the area is very appropriate for irrigation, but there are only a very few residents with more favourably located land who engage in it. Irrigation is mostly practiced by Campo Alegre farmers in other areas as they tend to rent plots of land in other locations to do that especially. This is especially the case during severe drought crisis.

Like Rosário, Campo Alegre also benefited from investments in the form of grants, but to a lesser extent. The government constructed a communitarian cheese factory and a *Casa de Farinha*, i.e. manioc flour mill. The government also invested in rural electrification, but since the community is very spread out, only part of the area has access to this service. The Campo Alegre residents do not have title to the land they occupy, nevertheless, such as in Rosário, they were encouraged to apply for loans to invest in infrastructure and animals. They have also had serious problems with repaying the loans and the majority of them have been unable to do so.

As a result of the scarcity of water to cultivate their crops, Campo Alegre inhabitants are devoted to livestock raising. The most important cultivated crops are manioc, corns and beans. The Campo Alegre residents seem to be poorer than the Rosário ones. The *assentamento* faces the same situation as Rosário, several people have sold their plots and have later returned and belong to the landless group. The area is not as crowded as Rosário because the dwelling houses are grouped in several *agrovilas* and not in one village as is the case in Rosário.

The boundaries of Campo Alegre are not well defined. Even the residents themselves do not have a clear idea of its boundaries. In contrast with Rosário, which is concentrated in one area, Campo Alegre is cut by several medium sized properties owned by Pesqueira people. The problems of water are very serious, there are few wells and some are not being used. There is also a desalination plant that does not work. Thus, the *carro-pipa* (water truck) is an important source of water for them. The people of Campo Alegre are dependent for their drinking water on the municipal authorities which deliver water to individual households in water trucks.

Moreover, Campo Alegre lacks a strong and solid social organisation and there are community factions. The local Association is in the hands of the better off and the president lives in Mutuca. According to Campo Alegre dwellers, he does not identify with the problems of the *assentamento* and has no interest in solving them, as he is not affected by them.

In previous times, the *Pão de Açucar* Dam, which is now located in the Xukurú area was an important source of water. However, until January 2004 it had not filled to its capacity for several years and thus water was not available to reach the Campo Alegre area. The Campo Alegre people have a contradictory relationship with the Xukurú population. While some of them get along well and have

even married Xukurú from the Reserve, others are very suspicious of the Xukurú, especially because the latter occupy a very important area in regards to water resources.

Campo Alegre also borders with Roçadinho, a village composed of former landless Peixe workers. Although the area where Roçadinho is located was owned by the Peixe Industry, it did not become an *assentamento* and instead was sold to farmers from Pesqueira. The Roçadinho residents thus only occupy the village houses and the community is formed by fifty families. According to Roçadinho dwellers as well as to people from Campo Alegre, the area did not become an *assentamento* because local landowners had interest in buying it and the former Peixe workers living there did not ask for indemnity when they found out that the industry was closing down. The Roçadinho population is very poor and there are virtually no water sources to supply the needs of the population. Besides some small ponds, there is a dam located in a Campo Alegre plot next to it, which is utilised by the Roçadinho population. The dam was constructed with public funds and during that time, the beneficiary, i.e. the owner of the plot, signed a document stating that the water was going to be available to the Roçadinho people.

Besides the areas occupied by Roçadinho and the Xukurú, most of the surrounding land is owned by local landowners.

(iii) Mutuca

Campo Alegre is geographically close to Mutuca and the population of each of the areas maintains a good relationship despite the differences in land tenure structure and organisation. Mutuca District in Pesqueira, the third Project site, has a population of 2 720 inhabitants. Most people in the Campo Alegre area relate socially and economically to the small market town of Mutuca. It is quite distinct from both Rosário and Campo Alegre as it is not an *assentamento* area, neither was it ever owned by the Peixe Industry. The area of Mutuca is larger and besides several rural properties many of those who own land live in the small town. The area benefits from some irrigation activity, however, the basis of the economic activities is animal raising, mainly cattle and the commercialisation of dairy products. Due to the limitation of time during the inception phase, there has not been attention devoted to the understanding of the socio-development aspects in Mutuca as this will be done at the beginning of Year 2 of the Project. The geographical area known as Mutuca in which a number of the groundwater dams are situated is not only located in the Municipality of Pesqueira but also, to the northeast, in the Municipality of Belo Jardim.

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Appendix A: Initial Review of Literature

Appendix B: National Water Resources Policy

Wherein the National Water Resource Policy is established; the National Water Resource Management System is created; regulations are provided for Paragraph XIX, Article 21, of the Federal Constitution; and Article 1 of Law No. 8,001 dated March 13, 1990, which had amended Law No. 7,990 dated December 28, 1989, is in turn amended.

I, THE PRESIDENT OF THE REPUBLIC,

HEREBY DECLARE that the National Congress has decreed and I have approved the following Law:

TITLE I
NATIONAL WATER RESOURCES POLICY

CHAPTER I

BASIC PRINCIPLES

Art. 1. The National Water Resource Policy is based on the following principles:

1. Water is public property;

2. Water is a limited natural resource, which has economic value;

3. When there is a shortage, priority in the use of water resources is given to human consumption and the watering of animals;

4. The management of water resources should always allow for multiple uses of water;

5. The river basin is the territorial unit for the implementation of the National Water Resources Policy and the actions of National Water Resources Management System;

6. The management of water resources should be decentralized and should involve participation by the Government, the users, and the communities.

CHAPTER II

OBJECTIVES

Art. 2. The objectives of the National Water Resources Policy are as follows:

7. To ensure that present and future generations have the necessary access to water of a quality adequate for their various uses;

8. To ensure the rational and integrated use of water resources, including transportation by aqueduct, with a view to achieving sustainable development;

9. To prevent and protect against water crises due to either natural causes or the inappropriate use of natural resources.

CHAPTER III

GENERAL GUIDELINES FOR ACTION

Art. 3. The implementation of the National Water Resources Policy shall be guided by the following general criteria:

10. Systematic management of water resources with equal regard to quantity and quality;

11. The adjustment of water resources management to the physical, biotic, demographic, economic, social, and cultural differences between the various regions of Brazil;

12. The integration of water resources management with environmental management;

13. The coordination of water resources planning with that of the user sectors and with planning at the regional, state, and national levels;

14. The coordination of water resources management with that of land use;

15. The integration of river basin management with that of estuary systems and coastal zones.

Art. 4. The Federal Union shall coordinate with the States on the management of water resources of common interest.

CHAPTER IV

INSTRUMENTS

Art. 5. The instruments of the National Water Resources Policy are as follows:

16. The Water Resources Plans;

17. The classification of bodies of water according to the principal uses made of their water;

18. The award of rights to the use of water resources;

19. Fees for the use of water resources;

20. Compensation to municipalities;

21. The Water Resources Information System.

SECTION I

WATER RESOURCES PLANNING

Art. 6. The Water Resources Plans are master plans that undertake to provide bases for and orient the implementation of the National Water Resources Policy and water resources management.

Art. 7. The Water Resources Plans are long-term plans, with a planning horizon compatible with the period over which their programs and projects are to be implemented, and shall contain at least the following:

22. Diagnoses of the current status of water resources;

23. An analysis of alternatives for population growth, for the evolution of production activities, and for changes in land-use patterns;

24. A statement of the future supply of and demand for water resources in terms of both quantity and quality, and an identification of potential areas of conflict;

25. Targets for rationalizing the use, increasing the volume, and improving the quality of the water available;

26. Measures to be taken, programs to be developed, and projects to be implemented for attaining the targets envisaged;

27. Vetoed.

28. Vetoed.

29. Priorities for the award of water-use rights;

30. Guidelines and criteria for water-use fees;

31. Proposals for the creation of areas subject to restrictions on water use, with a view to protecting water resources.

Art. 8. Water Use Plans shall be developed by river basin, by State, and for the country as a whole.

SECTION II

CLASSIFICATION OF BODIES OF WATER ACCORDING TO PRINCIPAL WATER USES

Art. 9. The classification of bodies of water according to the principal uses made of their water shall have the following objectives:

32. To ensure a level of water quality that is compatible with the most demanding uses for which the water is intended;

33. To reduce the cost of combating water pollution through constant preventive actions.

Art. 10. The classes of bodies of water shall be established by environmental legislation.

SECTION III

AWARD OF WATER-USE RIGHTS

Art. 11. The objectives of the water-rights guidelines are to ensure the quantitative and qualitative control of water use and the effective exercise of rights of access to water.

Art. 12. Rights to the following water uses are subject to Government award:

34. The diversion or impoundment of water from a body of water for final consumption, including public water supply or use in a production process.

35. The extraction of water from subterranean aquifers for final consumption or for use in a production process

36. The discharge of treated or untreated sewage and other liquid or gaseous waste into a body of water with a view to diluting, transporting, or disposing of it;

37. The utilization of hydroelectric potential;

38. Other uses that affect the flow, quantity, or quality of water existing in a body of water.

The following, as defined in the regulations, do not require Government award:

39. The use of water resources to meet the needs of small population groups scattered in rural areas;

40. Diversions, catchments, or discharges that are considered insignificant;

41. Impoundments of volumes of water that are considered insignificant.

The award and utilization of water resources for the generation of electric power shall be provided for the National Water Resources Plan, as approved in the manner set forth in paragraph VIII, Art. 35, of the present Law, subject to compliance with the legislation of the specific sector.

Art. 13. All awards shall be subject to the priorities for land use established in the Water Resources Plans and shall respect the class to which the body of water has been assigned and, when applicable, the maintenance of conditions suitable for transport via aqueduct.

Sole Paragraph. The award of rights to water shall maintain its multiple use.

Art. 14. The award shall be made by the responsible authority of the Executive Branch of the Federal Government, of the States, or of the Federal District.

42. The Federal Executive Branch may delegate to the States and to the Federal District the authority to award rights to the use of water resources that are their property of the Union.

43. Vetoed.

Art. 15. The award of rights to the use of water may be partially or entirely suspended, either indefinitely or for a specified period of time, in the following circumstances:

44. Failure to comply with the terms of the award;

45. Failure to use the resources for three consecutive years;

46. An urgent need for water in the event of a disaster, including those caused by adverse weather conditions;

47. A need to prevent or reverse major environmental degradation;

48. A need to provide for priority uses in the interest of the community, when there are no alternative sources;

49. A need to preserve the navigability of the body of water.

Art. 16. No award for water use shall be made for a period exceeding thirty-five years, which may be renewed.

Art. 17. Vetoed.

Sole Paragraph. Vetoed.

Art. 18. The award in no way implies partial alienation of the water itself, which is inalienable; it merely awards the right to use it.

SECTION IV

FEES FOR WATER USE

Art. 19. Fees for the use of water are intended:

50. To recognize that water is an economic good and give the user a sense of its real value;

51. To encourage the rationalization of water use;

52. To raise revenue for financing the programs and interventions provided for in the Water Resources Plans.

Art. 20. Fees shall be charged for the use of water resources subject to award under the terms of Art. 12 of the present Law.

Sole Paragraph. Vetoed

Art. 21. In the setting of fees for the use of water resources, the following elements, among others, should be taken into account:

53. In diversions, catchments, and extractions of water, the volume removed and the variation in its flow;

54. In the discharge of effluents and other liquid or gaseous waste, the volume discharged, the variation in its flow, and the physical-chemical and biological characteristics and toxicity of the effluent.

Art. 22. In the allocation of funds collected from fees for the use of water, priority shall be given to the river basin in which they were generated, and they shall be applied toward:

55. Financing studies, programs, and projects under the Water Resources Plans;

56. Defraying implementation costs and administrative overhead for agencies and entities of the National Water Resources Management System.

1. The payment of the costs referred to in paragraph II of the present article shall be limited to seven and one-half percent (7.5%) of the total amount collected.

2. The funds mentioned at the beginning of this article may be applied without limitation to projects and public works that alter, in a manner considered to be of benefit to the community, the quality, quantity, and flow rate of a body of water.

3. Vetoed.

Art. 23. Vetoed.

SECTION V

COMPENSATION TO MUNICIPALITIES

Art. 24. Vetoed.

SECTION VI

WATER RESOURCES INFORMATION SYSTEM

Art. 25. The Water Resources Information System is a system for the collection, processing, storage, and retrieval of information on water resources and the factors involved in their management.

Sole Paragraph. The data generated by the agencies in the National Water Resources Management System shall be included in the National Water Resources Information System.

Art. 26. The operation of the Water Resources Information System shall be governed by the following principles:

57. Decentralization of the gathering and production of data and information;

58. Standardized coordination of the system;

59. Guaranteed access to the data and information for the whole society.

Art 27. The objectives of the National Water Resources Information System are:

60. To collect, standardize, and disseminate data and information on the quality and quantity of water resources in Brazil;

61. To update regularly information on the availability of and demand for water resources throughout the national territory;

62. To provide subsidies for the preparation of the Water Resources Plans.

CHAPTER V

APPORTIONMENT OF COSTS FOR MULTIPLE-USE PROJECTS

OF COMMON OR COLLECTIVE INTEREST

Art. 28. Vetoed.

CHAPTER VI

ACTION BY THE GOVERNMENT

Art. 29. In the implementation of the National Water Resources Policy, the functions of the Federal Executive Branch are:

63. To take the steps necessary for the implementation and operation of the National Water Resources Management System;

64. To award rights to the use of water resources, and regulate and monitor such use within its sphere of competence;

65. To institute and manage the Water Resources Information System at the national level;

66. To promote the integration of water-resources management with environmental management.

Sole Paragraph. The Federal Executive Branch shall designate by decree the agency responsible for the award of rights to the use of water resources that are the property of the Union.

Art. 30. In the implementation of the National Water Resources Policy, the Executive Branches of the States and the Federal District shall have the following responsibilities within their sphere of competence:

67. To award rights to the use of water, and to regulate and monitor such usage;

68. To exercise technical supervision of water-supply projects;

69. To institute and manage the Water Resources Information System at the level of the States and the Federal District;

70. To promote the integration of water-resources management with environmental management.

Art. 31. In implementing the National Water Resources Policy, the Executive Branches of the Federal District and the municipalities shall promote the integration of the local policies on basic sanitation, land use and occupancy, soil conservation, and environmental protection with the Federal and State policies on water resources.

TITLE II

NATIONAL WATER RESOURCES MANAGEMENT SYSTEM

CHAPTER I

OBJECTIVES AND COMPOSITION

Art. 32. The National Water Resources Management System is hereby created, with the following objectives:

71. To coordinate integrated water management;

72. To arbitrate at the administrative level any conflicts related to water resources;

73. To implement the National Water Resources Policy

74. To plan, regulate, and supervise the use, conservation, and recovery of water resources;

75. To encourage the charging of fees for use of water resources.

Art. 33. The National Water Resources Management System shall comprise the following:

76. The National Council on Water Resources;

77. The State and Federal District Councils on Water Resources;

78. The River Basin Committees;

79. The organs at the Federal, State, and municipal levels whose respective areas of competence are related to the management of water resources;

80. The Water Agencies

CHAPTER II

NATIONAL COUNCIL ON WATER RESOURCES

Art. 34. The National Council on Water Resources is composed of:

81. Representatives of the Presidential Ministries and Departments concerned with the management or use of water resources;

82. Representatives designated by the State Councils on Water Resources;

83. Representatives of users of water resources;

84. Representatives of civil organizations concerned with water resources.

Sole Paragraph. The number of representatives of the Federal Executive Branch may not be more than half plus one of the total number of members of the National Council on Water Resources.

Art. 35. The National Council on Water Resources has the following responsibilities:

85. To promote the integration of water resources planning with planning at the national, regional, and state levels and with the user sectors;

86. To arbitrate, as the final administrative recourse, conflicts between State Councils on Water Resources;

87. To review water resources utilization projects whose impact extends beyond the States in which they are to be implemented;

88. To discuss any questions that have been submitted to them by the State Councils on Water Resources or the River Basin Committees;

89. To review proposals for amending existing legislation on water resources and the National Water Resources Policy;

90. To establish supplementary guidelines for the implementation of the National Water Resources Policy, the application of its instruments, and the operations of the National Water Resources Management System;

91. To approve proposals for the creation of the River Basin Committees and to establish broad criteria for the setting of their rules;

92. Vetoed.

93. To monitor the execution of the National Water Resources Plan and decide on the measures required for its goals to be met;

94. To establish broad criteria for the award of rights to water use and for the fees to be charged.

Art. 36. The National Council on Water Resources shall be managed by:

95. A Chairman, who shall be the Minister of Environment, Water Resources, and Legal Amazonia;

96. An Executive Secretary, who shall be the head of the organ within the Ministry of Environment, Water Resources, and Legal Amazonia that is responsible for the management of water resources.

CHAPTER III

RIVER BASIN COMMITTEES

Art. 37. The River Basin Committees shall act in the following spheres:

97. An entire river basin;

98. The river sub-basin of any tributary to the principal watercourse of the basin, or any tributary of that tributary; or

99. A group of contiguous river basins or sub-basins.

Sole Paragraph. The establishment of River Basin Committees for rivers that are the property of the Union shall be by act of the President of the Republic.

Art. 38. River Basin Committees shall have the following responsibilities in their respective areas of action:

100. To promote the discussion of issues relating to water resources, and to coordinate the work of the entities involved;

101. To arbitrate, as the first administrative recourse, conflicts relating to water resources;

102. To approve the Water Resources Plan for the river basin;

103. To monitor the execution of the Water Resources Plan for the river basin and suggest the measures required for its goals to be met;

104. To propose to the State and National Councils on Water Resources which impoundments, diversions, catchments, and discharges are of minor importance for purposes of exemption from the necessity of obtaining an award of water-use rights, depending on the ownership of the water;

105. To establish mechanisms for the receipt of fees for the use of water resources and suggest the fees to be charged;

106. Vetoed.

107. Vetoed.

108. To establish criteria for and promote the apportionment of the cost of multiple-use projects of common or collective interest.

Sole Paragraph. Decisions of the River Basin Committees may be appealed to the State or National Councils on Water Resources, depending on their respective sphere of competence.

Art. 39. The River Basin Committees are composed of representatives of:

109. The Federal Government;

110. The States or the Federal District in which they are located, even if only partially, in their respective areas of action;

111. The Municipalities in which they are located, entirely or in part, in their areas of action;

112. The water users in their areas of action;

113. Civil water-resources agencies that have a demonstrated record of action in the basin.

1. The number of representatives from each sector mentioned above, and the criteria for their appointment, shall be determined in the regulations of the committees; the representation of the executive powers of the Federal Government, the States, the Federal District, and the Municipalities shall be limited to half the total number of members

2. In the case of River Basin Committees that share in the management of basins of rivers that run along and across borders, the representatives of the Union must include one from the Ministry of Foreign Affairs.

3. The River Basin Committees of basins whose territory includes indigenous lands must include representatives from:

114. The National Indian Foundation (FUNAI), as part of the representation of the Union;

115. The indigenous communities living or having interests in the basin.

4. The participation of the Union in River Basin Committees whose sphere of action is limited to river basins belonging to a State shall be governed by their respective regulations.

Art. 40. River Basin Committees will be directed by a Chairman and a Secretary, elected from among its members.

CHAPTER IV

WATER AGENCIES

Art 41. The Water Agencies shall serve as the executive secretariats of the River Basin Committees.

Art. 42. The Water Agencies shall have the same area of action as one or more River Basin Committees.

Sole Paragraph. The creation of Water Agencies shall be authorized by either the National or the State Councils on Water Resources at the request of one or more River Basin Committees.

Art. 43. The creation of a Water Agency is subject to the fulfilment of the following requirements:

116. The prior existence of the River Basin Committee or Committees;

117. Financial viability ensured by fees for the use of water resources in its area of action.

Art. 44. Water Agencies shall have the following responsibilities within their area of action:

118. To maintain an up-to-date register of water resources available in their area of action;

119. To maintain a roster of users of the water resources;

120. To collect fees for water use, under authority delegated by the grantor;

121. To review and comment on proposals for projects to be financed from fees collected for water use, and transmit their comments to the financial institution responsible for administering these resources;

122. To monitor the financial management of fees collected for water use in their area of action;

123. To manage the Water Resources Information System in their area of action;

124. To enter into agreements and contracts for the financing and services with which to carry out their responsibilities;

125. To prepare a budget proposal and submit it for review by the respective River Basin Committee(s);

126. To arrange for the studies necessary for the management of water resources in their area of action;

127. To prepare the Water Resources Plan for review by the corresponding River Basin Committee;

128. To propose to the corresponding River Basin Committee or Committees:

129. The classification of bodies of water according to their use, for transmittal to the appropriate National or State Councils on Water Resources, depending on their ownership;

130. The fees to be charged for water use;

131. The plan for the application of the fees collected for water use;

132. The apportionment of costs of multiple-use projects of common or collective interest.

CHAPTER V

EXECUTIVE SECRETARIAT OF THE

NATIONAL COUNCIL ON WATER RESOURCES

Art. 45. The body within the Ministry of Environment, Water Resources, and Legal Amazonia responsible for the management of water resources shall serve as the Executive Secretariat of the National Council on Water Resources.

Art. 46. The Executive Secretariat of the National Council on Water Resources shall have the following responsibilities:

133. To provide administrative, technical, and financial support to the National Council on Water Resources;

134. To coordinate the preparation of the National Water Resources Plan and submit it to the National Council on Water Resources for approval;

135. To report on the proceedings of the State Councils on Water Resources and the River Basin Committees;

136. To coordinate the Water Resources Information System;

137. To prepare a work program and the corresponding annual budget proposal and submit them to the National Council on Water Resources for its approval.

CHAPTER VI

CIVIL WATER RESOURCES ORGANIZATIONS

Art. 47. For purposes of the present law, the following shall be considered civil water-resources organizations:

138. Intermunicipal consortia and associations dealing with river basins;

139. Regional, local, or sectoral associations of water users;

140. Technical, teaching, and research organizations concerned with the subject of water resources;

141. Nongovernmental organizations committed to defending broad collective interests of society;

142. Other organizations recognized by the National or State Councils on Water Resources.

Art. 48. In order to participate in the National Water Resources System, a civil water-resources organization must be legally constituted.

TITLE III

INFRACTIONS AND PENALTIES

Art. 49. The following shall constitute a violation of the statutes governing the utilization of surface-water or groundwater resources:

143. Diverting or using water resources for any purpose without having been awarded a right to that use;

144. Beginning to undertake or undertaking any action related to the diversion or utilization of surface-water or groundwater resources that alters their flow rate, quantity, or quality without prior authorization from the responsible agencies or entities;

145. Vetoed.

146. Using water resources or performing works or services related thereto in any way that contravenes the terms of the award;

147. Drilling wells for the extraction of groundwater, or operating such wells without due authorization;

148. Committing fraud in measuring the volume of water used, or declaring values that are different from those measured;

149. Violating rules established in the regulations and administrative provisions of the present Law, including instructions and procedures established by the responsible bodies or agencies;

150. Impeding or hampering the supervisory activities of the responsible authorities in the exercise of their duties.

Art. 50. For the violation of any law or regulation regarding the execution of hydraulic works and services, the diversion or utilization of water resources owned or administered by the Union, or for failure to respond to requests submitted, the violator, subject to the judgment of the responsible authority, shall be subject to the following penalties, listed in no particular order:

151. Written censure, with specification of a time limit for correcting the irregularities;

152. A single or daily fine proportional to the seriousness of the violation, ranging from R$ 100.00 (one hundred reals) to R$ 10,000.00 (ten thousand reals);

153. A temporary injunction, for a fixed period of time, to permit the performance of any services and activities necessary for effective compliance with the terms of the award or with the statutes and regulations concerned with the use, control, conservation, and protection of the water resources;

154. A permanent injunction, with revocation of the award if appropriate, to permit the restoration of the water resources, riverbed, and riverbanks to their previous condition, pursuant to Arts. 58 and 59 of the Water Code, or the capping of the wells being used to extract groundwater.

1. If the violation results in any impairment of the public water-supply service, risk to health or life, loss of goods or animals, or other damage of any kind to third parties, the fine to be imposed shall not be less than one-half of the maximum value agreed upon in abstract.

2. In the case of paragraphs III and IV, apart from the prescribed fine, the violator shall be charged for any costs incurred by the Administration to implement the measures stipulated in these paragraphs, pursuant to Arts. 36, 53, 56, and 58 of the Water Code, without prejudice to the payment of indemnity for any damage caused.

3. The imposition of the penalties provided for under this title may be appealed to the competent administrative authority under the terms of the regulations.

4. In the event that the violation is repeated, the fine shall be doubled.

TITLE IV

GENERAL AND TRANSITORY PROVISIONS

Art 51. The intermunicipal consortia and associations for river basins referred to in Art. 47 may receive delegated authority from the National or State Water Resources Councils for a specified period to carry out the duties for which the Water Agencies are responsible, prior to the establishment of the latter.

Art. 52. Until the National Water Resources Plan has been approved and regulated, the utilization of hydraulic potential for purposes of electricity generation shall continue to be governed by the specific sectoral legislation.

Art 53. Within one hundred and twenty days from the publication of this Law, the Executive Power shall submit a draft law to the National Congress on the creation of the Water Agencies.

Art. 54. Art. 1 of Law No. 8,001, dated March 13, 1990, hereby enters into effect with the following text:

"Art. I^{o} .....
..... III - Four and four-tenths per cent to the Secretariat of Water Resources of the Ministry of the Environment, Water Resources, and Legal Amazonia;

IV - Three and six-tenths per cent to the National Department of Water and Electrical Energy (DNAEE) of the Ministry of Mines and Energy;

V - Two per cent to the Ministry of Science and Technology.

.....

4. The quota allocated to the Secretariat of Water Resources of the Ministry of Environment, Water Resources, and Legal Amazonia shall be used for implementing the National Water Resources Policy and the National Water Resource Management System and for managing the national hydrometeorological network.

5. The quota allocated to the DNAEE shall be used for the operation and expansion of its hydrometeorological network, for studies on water resources, and for services related to the utilization of hydropower."

Sole Paragraph. The new percentages established at the beginning of this article shall enter into effect one hundred and eighty days from the date on which this Law is published.

Art. 55. The Federal Executive Branch shall issue regulations for this Law within one hundred and eighty days from the date of its publication.

Art. 56. This Law enters into effect on the date of its publication.

Art. 57. Any provisions to the contrary are hereby revoked.

Brasilia, January 8, 1997, 176th year of Independence and 109th year of the Republic.

FERNANDO HENRIQUE CARDOSO