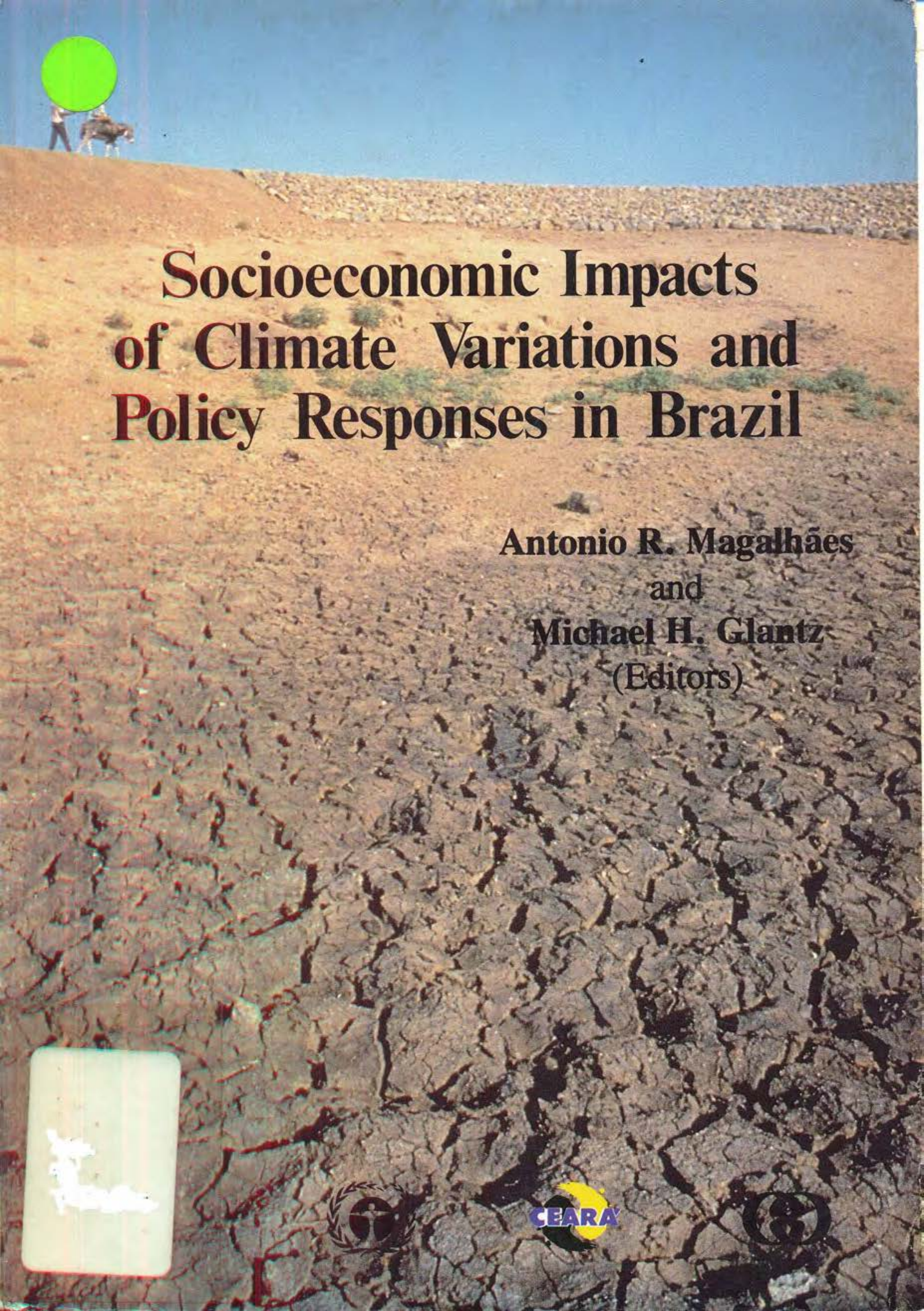

Socioeconomic Impacts of Climate Variations and Policy Responses in Brazil

Antonio R. Magalhães
and
Michael H. Glantz
(Editors)

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SAS - Q. 06 - Bl. L - Ed. ASCB - Conj. 801-A
70070 - Brasilia-DF, Brazil
Phone: (55) 061 - 322-2062
Fax: (55) 061 - 322-1063

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INTRODUCTION

In 1975, a severe frost in the state of Paraná virtually eliminated the coffee crop in that state, the main coffee producer in the country at the time. In 1983, the Brazilian Northeast was adversely affected by a devastating prolonged drought which culminated in five years of regional rainfall deficiencies. Droughts reappeared in 1987 and again in 1990. In 1988 and 1990, heavy floods devastated the city of Rio de Janeiro and neighboring regions and caused enormous human and economic losses. In 1991, floods inundated the city of São Paulo, causing panic, devastation and death.

Despite a variety of government and societal actions, the different regions of the country continue to be highly vulnerable to the hazards of climate variability. Indeed, vulnerability has been increasing due to human mismanagement of the natural resources and of the environment.

There has been considerable discussion in Brazil (and in many other countries) on the likelihood of climatic change caused by human activities, resulting in the emission of greenhouse gases and other radiatively active chemicals into the atmosphere. Such climatic change implies higher temperatures, sea level rise and increased frequency and intensity of extreme meteorological events such as the ones mentioned above. Given this possibility, it is very necessary that society become better prepared to deal with the changes by identifying and adopting strategies to enable us to better cope with the consequences of hypothesized but possible climate change. Indeed, the need to gain increased resilience to possible future climate change implies that it is first and foremost important to improve coping strategies for present climate variabilities.

This study is an attempt to understand the direct and indirect interactions between climate and society in Brazil. A set of climate impact case studies were identified and experts were selected to undertake these assessments. The 14 case studies include research on the salt industry, agriculture, electric power supply and demand, health and nutrition, the political aspects of droughts, flood and freeze damages, and so forth. Climate-related impact case studies were not undertaken in our study for the Amazon region because this region has received a large share of scientific and political attention both within Brazil and in the international community.

The reasoning behind this study was based on the prevailing view that general circulation models of the atmosphere are not able at the present time to provide regional climate change scenarios with sufficient reliability for climate impact assessment. As a result, a search for alternative methods to gain a glimpse of possible future societal responses to potential global climate change was pursued.

Our focus is on assessing societal responses to recent regional climate-related environmental change. Evaluation of such responses can help us to identify strengths and weaknesses in those responses to existing environmental changes. By identifying and addressing the weaknesses, we can better prepare society for an uncertain climatic future. While we are not in a position to forecast the future state of the atmosphere, we can assume that societal actions undertaken in the near future will be much like those undertaken in the recent past. Societal institutions, in general, change rather slowly. Lessons can be found in past experiences that can guide us into the future, allowing societies to maintain a higher degree of flexibility than might otherwise be the case.

It is important to stress that in many countries any new information about climate-society interactions can benefit decision makers, if that information is used judiciously. Thus, regardless of how and when the global climate might change, such historical assessments can serve as useful inputs into economic development planning activities. In addition, the study process has identified and brought together a set of researchers from a variety of disciplines, institutions, and research interests. Thus, the first stages of networking for climate impact assessment have begun.

This project was sponsored by the United Nations Environment Programme (UNEP) and the Government of the State of Ceará (in Brazil), and coordinated by the Ceará State Planning Secretariat (SEPLAN). Case studies were discussed and a common set of questions identified during a workshop in Brasilia organized by the Esquel Brazil Foundation (Fundaçao Esquel Brasil) in February 1990, with the participation of scientists and policymakers from Brazil, UNEP and from the National Center for Atmospheric Research (NCAR) in the USA.

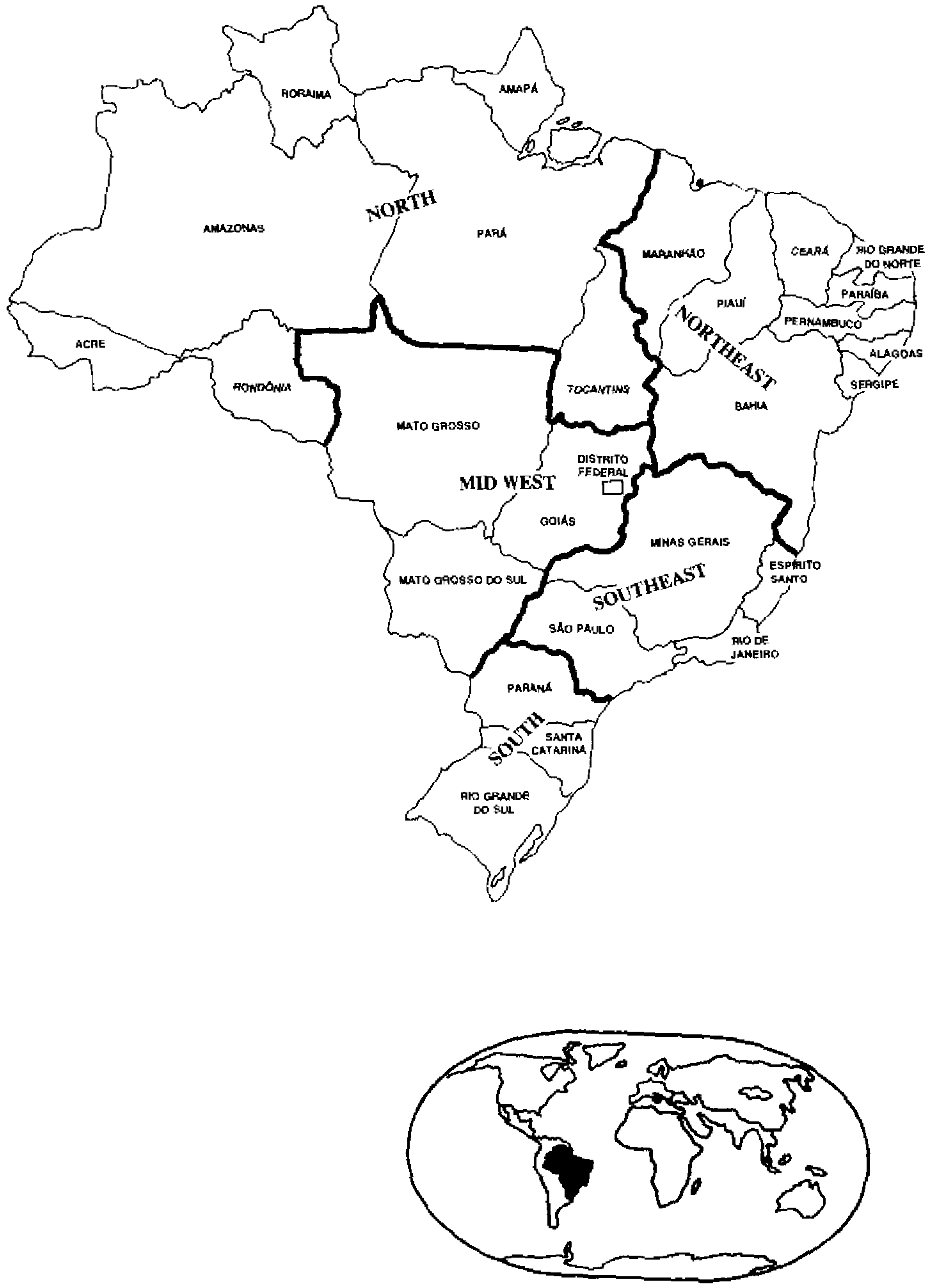
Our summary report is based on the research findings presented in the original full-text case studies. However, we have significantly reduced the length of each chapter and have consolidated some of the papers in order to avoid repetition. We therefore bear the responsibility for any misinterpretations that may have been inadvertently introduced into the summary.

Part I contains a discussion of the problems brought about by droughts in the Northeast of Brazil (also referred to as the Nordeste). Part II presents discussion of the impacts of droughts, as well as of floods and frosts, in different parts of Brazil.

The authors of this project summary report would like to acknowledge their high level of appreciation for the careful and patient support provided by Jan Stewart, in the Environmental and Societal Impacts Group (ESIG) at NCAR. Without her constant assistance, it would not have been possible to complete this report within the time available for the task. In particular, Antonio Magalhães wants to thank his family (Fatima, Eduardo, Marilia, and Marcos) for their unending patience during the long weekend hours when this work was being prepared.

Antonio R. Magalhães, Esquel Brasil
Michael H. Glantz, NCAR/ESIG

FIGURE 1 - Regions and States of Brazil



LIST OF CASE STUDIES SUMMARIZED IN THIS REPORT

The full text of each of these studies can be found in the following report:

Antonio R. Magalhães (Esquel Brasil) and Eduardo Bezerra Neto, (Ceará State University), editors of the original case studies (mimeo volume in Portuguese and in English), Socioeconomic Impacts of Climatic Variations and Policy Responses in Brazil. Fortaleza, Ceará, Brazil. UNEP/SEPLAN. 1989.

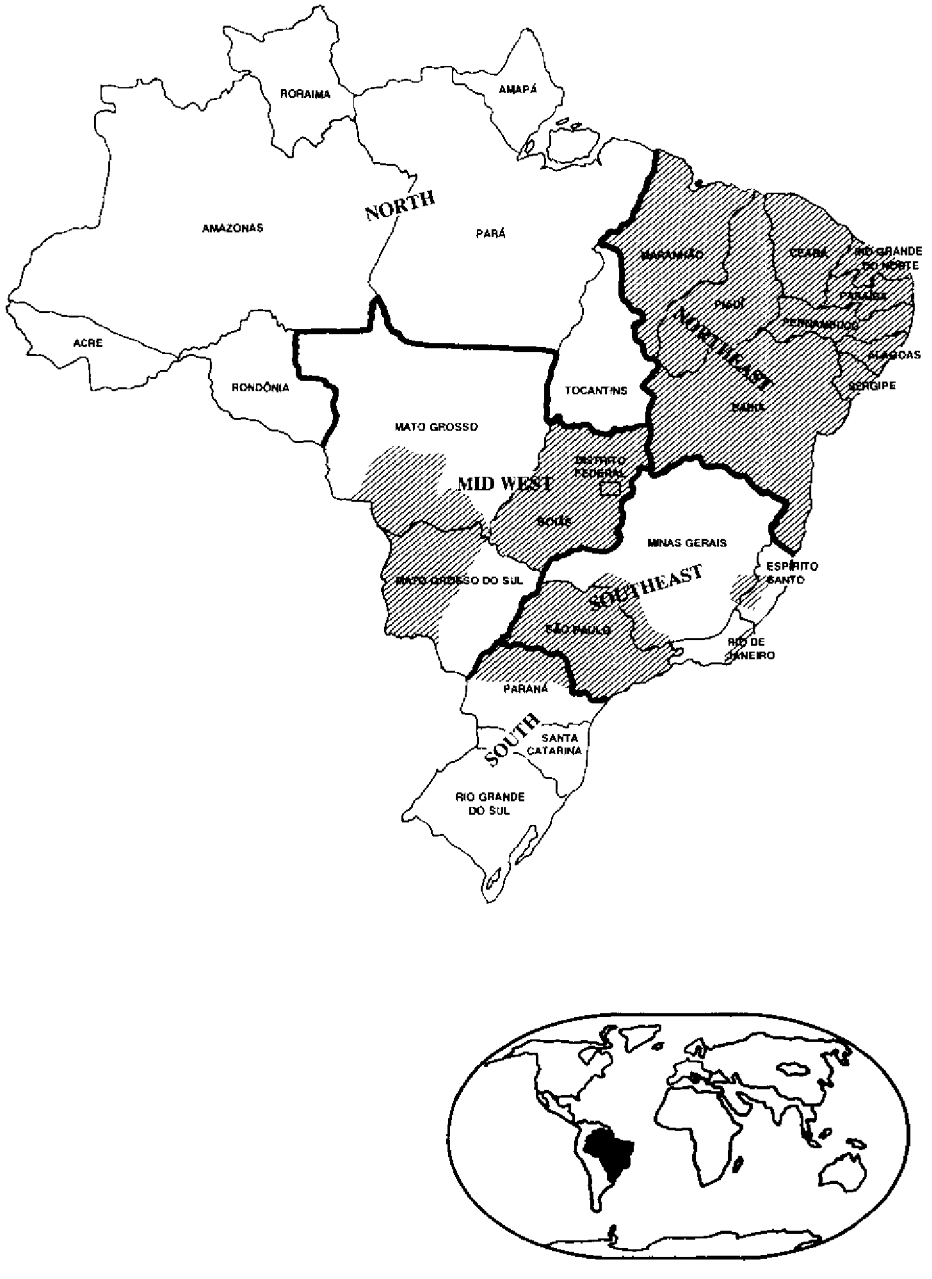
1 *The Effect of Droughts on the Economy of the State of Ceará*
Almir C. Fraga and Agamenon T. de Almeida, Federal University of Ceará

2 *The Effect of Drought on Occupational and Employment Characteristics of the State of Ceará in the Eighties*
Liana M. Carleial and Aécio A. de Oliveira, Federal University of Ceará

3 *The Effect of Drought on Public Finances in the State of Ceará*
Ronaldo A. Arraes and Ivan Castelar, Federal University of Ceará

4 *Effects of Drought on Health and Nutrition in Brazil's Northeast.*
Marcelo G.C. da Silva, State University of Ceará

FIGURE 2 - Localization Case Studies



PART I

DROUGHTS IN BRAZIL'S NORTHEAST

Photo by Carlos Namba/Abril Imagens

Seca: Flagelados no Nordeste/Drought: migrants from the drought region/Northeast

NORTHEAST BRAZIL: AN INTRODUCTION

The Brazilian Northeast (the Nordeste) is one of the five macro-regions of Brazil. It occupies 18.2% of the Brazilian territory, accounting for 1.5 million square kilometers. Present population (1990) is about 43 million people, representing 28.5% of the country's total.

The Nordeste is an underdeveloped part of Brazil. Although economic growth has been rapid during the 1970s and in some years of the 1980s, the level of per capita income is still very low (around US$ 800 per year) and the income distribution is very skewed. As a result, a great part of the population is situated below the poverty line, which makes the Nordeste a region of large net out-migration.

Ecologically, the region is very diverse, with at least six different, well-defined eco-regions. Each one is comprised of several sub-ecosystems: the semiarid backlands or "sertão"; the coastal humid forest zone or "zona da mata"; the "agreste", a transition zone between the zona da mata and the sertão; the "cerrados", a savannah-type area in western Nordeste; the pre-Amazonian transition zone; and the several micro-climates within the sertão (see Figure 3).

Politically, the region is divided into nine states. From North to South, these states are: Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia (see Figure 1).

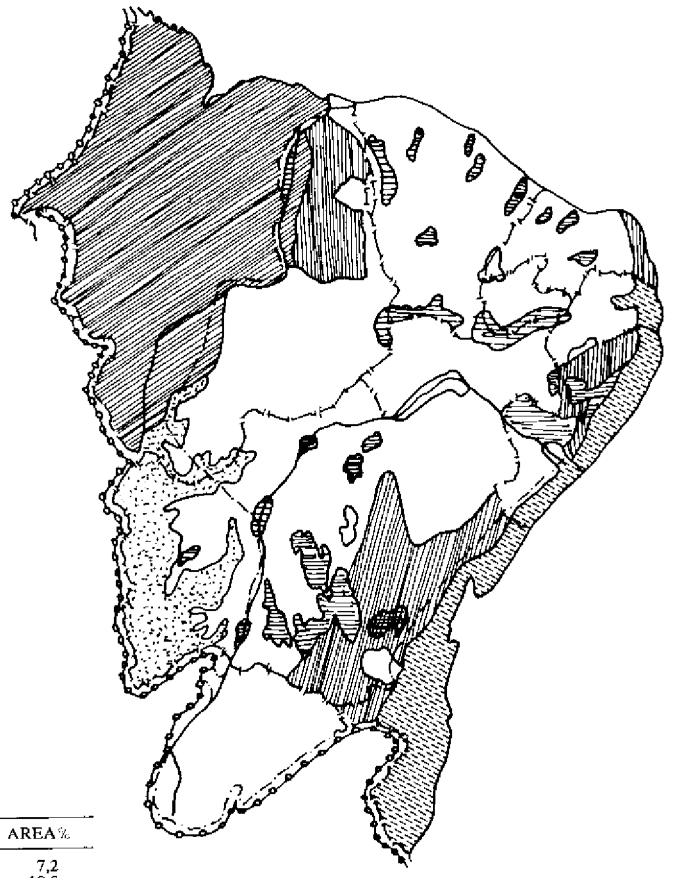
The semiarid, as it is called, is the largest ecosystem, comprising 60% of the total area of the Nordeste. It encompasses a part of each of the Northeastern states, except for Maranhão. On its southern portion, the semiarid penetrates the state of Minas Gerais, which is in the Southeast region. Some of the states are mostly semiarid, such as Ceará, Rio Grande do Norte, Paraíba and, to a lesser degree, Pernambuco and Bahia. In all of them, the semiarid ecosystem constitutes a great challenge, because of the variability of regional climate, the scarcity and fragility of natural resources and the patterns of human occupation. Indeed, as a result of historical factors, the semiarid has been heavily occupied and its environment overexploited for many years.

One of the important characteristics of the semiarid is recurrent intense drought episodes. Droughts heavily affect the population, the economy (especially agriculture), and natural resources, and is a cause for periodic out-migrations. Clearly, the region as a whole is very vulnerable to droughts.

In this section of our study (Part I), we present the results of several papers on impacts of droughts in the semiarid Nordeste, based primarily on the research for the UNEP/Ceará State Planning Secretariat (SEPLAN) project. These studies deal with the impacts of drought on the economy as a whole, on the employment sector, public finances, health and nutrition, and on politics.

The remaining studies in this section are concerned with the search for new methodologies for dealing with droughts and with the experience of responding to droughts in the Nordeste. The lessons provided by these studies could well be useful not only for the improvement of the knowledge about the nature and consequences of drought, but especially for the improvement of the policy responses in the face of a possible increase in the intensity, duration and frequency of future droughts that are supposed to result from likely climatic changes.

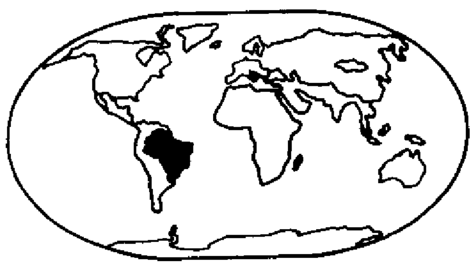
FIGURE 3 - Ecological-Economical Zones of Northeast



GEO-ECONOMIC ZONES	AREA %
Coastland and forest	7,2
Agreste	10,8
Semiarid	52,4
Middle North	22,4
Fertile Spots (Mountein ranges and irrigation basins)	2,4
Cerrado	4,8

B ——– Drought Polygon Line
C —⊢⊣— Interstate Limit
D —•—o— Limit of the SUDENE Acting Area

Based ond Carvalho, Otamar et allii (1973), "Plano Integrado para o Combate Preventivo aos Efeitos da Seca no Nordeste", Brasília, Minter



Trabalhadores na época de seca/Workers in the drought

Chapter **1**

THE EFFECTS OF DROUGHT ON THE ECONOMY[1]

Northeast Brazil (the Nordeste) is a region with a developing economy that is comprised of a small but modern manufacturing sector and a larger traditional manufacturing sector concentrated in the important coastal cities of Recife, Salvador and Fortaleza, of traditional cash crop agriculture in the humid coastal or forestry zone (mainly sugar cane and cocoa production) and an extensive subsistence agricultural activity in the semiarid backlands (called the sertão).

Table 1 compares a non-drought year (1978) with a drought year (1983); the sectoral composition of the regional gross domestic product (GDP) is as follows:

Table 1
Northeast Brazil
Sectoral Composition of GDP

Sector	Non-drought year (1978)	Drought year (1983)
Agriculture	18.2	7.6
Manufacturing	23.8	23.6
Services	58.0	68.8

Source: Arraes and Castelar, 1989; Table 2.

1 Based on A. R. Magalhães and O. Rebouças, "Introduction: Drought as a Policy and Planning Issue in Northeast Brazil." In M. L. Parry et al. (ed), *The Impact of Climate Variations on Agriculture,* Vol.2, Assessmentes in Semiarid Regions. UNEP/IIASA Project, Kluwer Academic Press, Dordrecht, 1988; Almir C. Fraga and Agamenon T. Almeida, 1989: "The Effect of Drought on the Economy of the State of Ceará", in A. R. Magalhães and. E. Bezerra Neto (eds.), *Socieconomic Impacts of Climatic Variations and Policy Responses in Brazil.* UNEP/SEPLAN-CE, Fortaleza, (unpublished research report); and Ronaldo A. Arraes and Ivan Castelar, "The Effect of Drought on Public Finances in the State of Ceará", in A. R. Magalhães and E. Bezerra Neto (eds.), op. cit.

The relatively high degree of climatic variability in the Brazilian Northeast (also referred to as the semiarid) affects the regional economy in several ways and to different degrees. Subsistence agriculture in the semiarid is the most affected part of the agricultural sector. This is a very important sector of the economy of the Northeast. In some states, for example Ceará, almost 90% of the agriculture output comes from the semiarid.

Droughts and the Economy

When drought and economics are discussed together, major emphasis has to be placed on the agricultural sector. In drought years, the share of farming's contribution to the GNP is greatly reduced, with the services sector of the economy making up the difference. Manufacturing remains practically unchanged.

An econometric analysis by Arraes and Castelar has shown that, in the case of the state of Ceará (a typical semiarid state in the Northeast):

- the manufacturing product has been positively related to droughts, i.e., manufacturing gross product increases during drought years;
- the services product is also positively related to droughts;
- the farming product, however, is negatively related to droughts, as might be expected.

Their study, however, does not attempt to separate the effects of drought impacts from those of government responses to those impacts. The positive correlation of the manufacturing and services sectors is likely to occur as a consequence of governmental responses that increase monetary incomes, through wage payments and the purchase of inputs to be used in drought-related emergency programs. The combined direct and indirect effect of these payments are a cause for increasing the local demand for manufactured goods and services.

Without government responses like those carried out in Northeast Brazil, it is expected that the manufacturing sector could be marginally affected by drought (because of lower local demand and higher input prices), while the productivity of the services sector could indeed diminish. With respect to the modern branch of industry, its sensitivity to drought is even less, since for the most part it is export-oriented (to national and foreign markets) and its dependency on regional agriculture negligible. In addition, this sector has been successful in importing substitutes for needed inputs.

The Agricultural Sector

Agriculture, however, is highly sensitive to climate variations. In the semiarid Northeast, where rainfall is skewed to dryness, agriculture is normally a high-risk activity, especially because most of it is based on dryland farming, a low productivity activity. It is highly vulnerable to recurrent, often prolonged droughts. In the semiarid Northeast the agricultural activity is based on food crops (subsistence crops produced by small farmers), cotton (produced by small and large farmers), and cattle raising by large landowners.

Small farmers' food crops are greatly affected by droughts. A comparison of a drought year (1987) with a non-drought year (1986) for a typical semiarid *municipio* (Crateus, in the State of Ceará) shows the following:

a) if drought occurs at the beginning of the rainy season, some farmers decide not to plant. In 1987, for example, the planted area diminished by 8.1%. In other *municipios* (counties), like Iguatu, this decline was as high as 48%;
b) the drop in basic food production amounted to 63.3% in the case of maize, 41.8% in beans and 93.9% in rice. In other *municipios*, this fall could have been even higher;
c) with respect to expected basic food production in 1987 (in Crateus), actual production turned out to be less than a fifth, as shown in Table 2:

Table 2
Municipality of Crateus, Ceará State
Impact of the 1987 Drought on Subsistence Agriculture

Crop	Actual/Expected Food Production
Maize	21%
Beans	25%
Rice	3%
Cotton	6%

d) a sharp decline in productivity levels (e.g., yields) is also observed in agriculture, especially in food production. Productivity losses in 1987 were as high as 60% or more, depending on the type of crop and its geographic location;
e) as a consequence, there is a large drop in farmers' and workers' incomes, which is reflected in a proportional decline in total agricultural income. In this process, the most affected group is the majority of the semiarid population which is dependent on agriculture, that is, mostly small farmers, rural workers and their families;
f) the diminished output of agricultural products leads to price increases in the marketplace, shortage of food supplies and requires commensurate imports (particularly of food) from other regions.

Droughts and Migration

Another important consequence of droughts in Northeast Brazil is the resultant increase in rural-urban migration, exacerbating the spatial expansion and densities of urban peripheries, the proliferation of slums and urban infrastructure shortages. Even in what many perceive to be "normal" years, there is much out-migration from the Northeast to other regions in Brazil, especially to the major economic centers of São Paulo and Rio de Janeiro. Today, drought is expected to result in an increase in migration. Government relief responses are designed, however, to reduce out-migration.

The socioeconomic conditions in rural areas, like the concentration of land ownership in the hands of a few, traditional labor relations which disfavor poor laborers, and the absence of basic governmental services in education and health, are major factors explaining the out-migration phenomenon. Droughts only contribute to an increase in these migrations.

Migration, whether a societal response to droughts or to adverse regional socioeconomic conditions, affects the regional economy. While on the one hand it contributes to reduce pressures on local resources, it is also a cause for weakening the regional rural economy, in the sense that those who migrate are most often the active and productive workers.

Relief Programs

Sooner or later, the government enacts emergency relief programs which generally consist of "workfronts" whereby unemployed workers sign up for government-sponsored construction jobs and receive a salary from the government. This system accomplishes a number of objectives:

- it keeps the workers and their families nourished
- it leads to a variety of infrastructural improvements
- it reduces migration from the rural to urban areas and to other regions

In the aggregate, the relief programs trigger a relatively huge injection of cash into the economy. As a result, exchanges which had previously been in kind become monetized. Through a multiplier effect, the decline in total regional (monetary) income is minimized if not arrested from further decline and, indeed, may under certain conditions increase, depending on the volume of government expenditures in wages and inputs.

In 1987, the State of Ceará alone enlisted 250,000 workers in such drought-related work programs, and the Northeast as a whole involved more than one million workers. In 1983, an extreme year of drought at the end of a multiyear drought situation, the total number of such enlistees in the Brazilian Northeast had surpassed 3 million workers.

Concluding Comments

Climate variability in the Northeast, especially in the form of recurrent prolonged droughts, has had a long history of severe economic, social and political consequences that still merit thorough analyses. The societal and governmental responses represent an invaluable experience whose lessons can be useful for the design of future policies in response to climate variability and change. In particular, the analysis of climatic impacts cannot be separated from the social, economic and environmental characteristics of the region. This implies the need for multi-disciplinary climate-related impact assessments, and for integration of such assessments into the search for sustainable development alternatives, especially in the face of an uncertain climate future.

Photo by Manoel Novaes/Abril Imagens

Seca: Açude/Drought: Dam (Juazeiro – Pernambuco)

Chapter **2**

THE EFFECTS OF DROUGHT ON OCCUPATION AND EMPLOYMENT[2]

Introduction

For centuries, the Brazilian Northeast has been considered a region in economic crisis. One of the factors responsible for this chronic condition, in the opinion of many investigators, is its highly variable climate, which is skewed to dryness. Under such conditions, droughts are relatively frequent and often devastating. Carleial and Oliveira, the authors of this paper, however, view the Northeast as a region not easily understood because of its complex economic and social relationships. For example, in the Northeast there coexist the most advanced forms of capital and old unresolved historical-structural barriers, such as a concentrated agrarian structure and income distribution and the absence of a generalized salaried work force.

In this discussion, poverty and wealth in the Northeast are considered to be concretely determined by social relationships. Drought episodes merely act to make more visible the poverty that reigns throughout the rural Northeast. This is explained by the nature of the relationship between drought and farm production. Economically speaking, drought would simply lead to a drop in production. Drought-related drops in production, however, occur in many parts of the world — e.g., in the US in 1987/88 — yet they are not followed by penury and hunger. Consequently, the gravity of

2 Based on the report by Liana M. Carleial and Aécio A. de Oliveira, "The Effect of the Drought on Occupational and Employment Characteristics of the State of Ceará in the Eighties." In Magalhães and Bezerra Neto, op. cit.

droughts in the Brazilian Northeast lies in the penury of the stricken population.

The penury that victimizes vast numbers of *nordestinos* (inhabitants of the semiarid Northeast) derives from the manner in which the latter participate in rural production. Again, economically speaking, drought often results in a reduction in agricultural production. This in turn should have effects in the remaining economic sectors, particularly commerce, state tax collections and transportation, among others.

That may also trigger a drop in the local economy's effective demand, which would then extend to the remaining, interconnected economic areas. It should be emphasized, however, that the drop in production will probably not be reflected completely in the records of the farm product. This is explained by Maia Gomes (Gustavo Maia Gomes et al., Recessão e desemprego nas regiõs brasileiras, Recife, PIMES/UFPE, 1985), on the assumption that a major part of farm production is not included in official statistics in normal times. Thus, the officially recorded drop in production caused by drought may be greatly underestimated.

The population most affected by the drought is usually released from its work and turned immediately into the temporarily unemployed. Since government relief programs do not start up instantaneously, idled workers feel forced to loot groceries and warehouses; unable to compete in the labor market they join (and swell) the ranks of the beggars. Not only are there few opportunities for alternative work in the towns, but lack of skills by the unemployed also blocks their way of access to urban types of employment.

From an occupational standpoint, the people most directly affected by the drought — small landholders, squatters, farm workers and sharecroppers — who previously had been listed in official statistics as "working population", are transformed instantly into an "idle population", i.e., devoid of either occupation or work.

Given the shrinking opportunities in the agricultural sector, the most immediate effect is intersector mobility from the farm to other sectors. Because of the limited opportunities offered by nearby small and medium-sized towns, drought victims often must sell their land (if they own it) and migrate.

This sequence is not strictly followed, because the government eventually starts up drought-relief programs, generally after there have been a number of lootings. Such programs employ at least part of the affected population in the so-called "emergency fronts". The most immediate effect is to encourage a major fraction of potential migrants to remain in their original regions. Another effect is to reduce their standard of living and to reinforce the dominant structure that makes it possible for droughts and the attendant penury to recur. In any event, government action provides some opportunities for intersector as well as intrasector adjustment to the effect of drought.

As far as the urban scene is concerned, there is a proliferation in government jobs charged with administering drought relief, such as teams to follow up on the governmental distribution of water and food, or on the welfare of migrants who managed to reach the towns and cities. From an employment perspective, in general, the most visible effect for the 1983 drought was a reduction in the total number of those employed in the rural areas and an increase in urban employment, particularly in the construction industry.

In addition, the launching of work fronts sets up a monetary flow, through payment to enlistees, that in many instances, depending on their salary, can (or cannot) properly reestablish their access to food (an access lost as a result of the drop in production). In aggregate terms this process increases the monetization of trade. This cash flow, in turn, stimulates imports of food as well as state and local commerce, affecting transportation and the collection of state taxes in ways that are difficult to measure with any degree of confidence. Thus, government transfer payments in times of drought could be designed to counterbalance the aggregate loss of income caused by the drop in production.

Some General Characteristics of the Region

Brazil's Northeast, with a productive structure that is incapable of providing jobs or occupations for its work force, must cope with additional difficulties whenever drought strikes. The Northeast's poverty and endemic hunger cannot be attributed to the occurrence of droughts. There are historical, structural and political factors which constrain the possibilities for improving the living conditions of large segments of the population.

The poorest segment of the population is the most vulnerable to drought. It consists of millions of rural workers, farmers with small land holdings, and their families. The extremely concentrated control of the agrarian structure and the traditionally inequitable working relationships between workers and landowners (e.g., sharecropping, tenant farming, squatting) contribute to, as well as serve as a cause to such a condition. Independent of droughts, the existing economic base is insufficient to provide decent living conditions for everyone. Undoubtedly, the drought is an additional factor in causing the displacement of field workers, either to the rural areas or to the towns, but it is not the primary cause of problems in the Brazilian Northeast.

Drought causes a sharp drop in agricultural activity — and production — prompting an immediate release of the rural labor force from their farming activities. Should those idled by the drought migrate (as they often do), they will probably fail to find work in the towns. The production structure itself is unable to absorb them, mainly because the idled persons are not even minimally qualified to work in urban areas, since 60% of them either never attended school or attended for one year or less. Thus, in the absence of even a modicum of schooling, the possibility of finding jobs in urban industries are practically nil. The only opportunities left are low paying, insufficient to provide for the adequate sustenance of workers and their families, regardless of whether they had chosen to migrate or not.

Income distribution among employed workers during the 1980s illustrates the levels of poverty of both field and city workers, using the official minimum salary as an indicator. During the period 1979-83, as that prolonged drought worsened, the numbers of those receiving up to one *salário mínimo* (about US$50.00 a month) swelled, proving that poverty was spreading in spite of the establishment by the government of work-fronts. From 1980 to 1983 the proportion of those workers whose average monthly income was less than one minimum salary was 58.7% for cities in the Ceará State and 87.6% for rural inhabitants.

1983 was the year in which living conditions for the workers were the worst. In the field, 91.1% of the working population was paid less than 1 *salário mínimo*, while in urban areas this proportion was 61.1%. Furthermore, records indicate that, beginning in 1984, the year after the prolonged drought, there occurred a drop in the proportion of those at the bottom of the pay pyramid, with the share of those earning less than a minimum salary decreasing to 76.6% in 1985.

These data show that governmental drought-relief action in 1983 did not maintain the rural, drought-stricken worker's income level during periods when climate was "normal." In other words, the drop in farm production was not compensated for by the payments received in the work or emergency-fronts. Such a situation usually occurs when there is a need for increasing the number of work-force enlistees at a time when the shortage of federal funds forces the government to decrease the real value of salaries paid to emergency workers.

The Relief Programs

Drought causes instantaneous and huge unemployment of the underemployed while causing almost no pressure on the urban labor market. In such a situation, Government relief programs play a very important role. During drought, the Government employed in work-fronts about 2.5 million workers in the Northeast, with an expenditure of US$375 million. In the state of Ceará alone, about 1 million jobs were temporarily created, compared to a total state labor force of 2.1 million workers.

It should be pointed out that the emergency plan introduced during the 1979-83 drought, according to SUDENE (the Superintendency for the Development of the Northeast), underwent major changes compared to previous plans. Aid to drought victims was changed; for example, victims no longer had to travel long distances to receive assistance. Instead, they could remain close to home, working on private property within their region.

1983 was a critical year. The number of workers in emergency fronts was almost 22% of the entire Economically Active Population (EAP) of the Northeast, and was 45% of its rural EAP. The funds spent on compensation amounted to 3.4% of the regional gross product, 12.1% of its industrial product, or 53.5% of the product of the construction industry.

In Ceará, the 1982-83 work-fronts/emergency-fronts enlisted a total number of workers that exceeded the rural EAP. This number includes workers living in small urban centers in this semiarid region. However, it may also be evidence in support of complaints that among these "needy" enlistees were people who were not really rural workers, but were merely recipients of political patronage.

The combined effects of drought and governmental relief response include:

a) a monetization of the regional rural economy and a consequent income multiplier effect that averts a fall (and sometimes causes an increase) in regional income;
b) a fall in agricultural employment and a corresponding increase in the services sector employment (e.g., civil construction). For instance, in 1983 the farming employment participation in the state of Ceará dropped from 41% (1982) to 14%, while construction participation rose from 7% to 35%. Part of this increase includes jobs created in civil works related to drought relief activities;
c) keeping the workers and their families relatively healthy, in addition to various kinds of infrastructure improvements.

It is obvious that the aggregate effect of drought on employment depends both on the intensity of droughts, the characteristics and size of the relief programs and the condition at the time of drought of the national and regional economies. Clearly, better integration of the relief programs with long-term policy objectives is required, not only in relation to the relief activities themselves (e.g., public works or other activities), but primarily in relation to relief employment policies. Basic criteria should include the value of the salary, the length of the work day and work week, the type of labor relationship between employer and employee, and the eligibility of workers for such relief assistance.

The Situation After Drought

In 1984, after the drought, participation in farm employment rose to 42%, while construction employment declined to 5%. The relief programs, for good or bad, achieved their objectives, but society remained as vulnerable as ever to the hazards of climate variability. The return to "normal" raises questions about how good or acceptable "normal" is.

Chapter 3

THE IMPACTS OF DROUGHTS ON PUBLIC FINANCES[3]

Introduction

This chapter discusses the effects of droughts on the finances of the state of Ceará. The time span under investigation is 1970-85, which includes droughts in 1970 and 1979-83. Part of the latter period (1981-83) coincided with a nationwide recession in Brazil.

Econometric models were generated through a recursive approach in order to identify the effects of climate and the level of economic activity — nationwide as well as statewide — on the main components of state revenues. This resulted in a simulation that made it possible to separate the individual and joint effects of these two factors (climate and level of economic activity) on state revenues.

Conventional wisdom usually assumed that drought years caused a substantial loss in the state's revenues, thereby explaining its inability to maintain a steady flow of public-sector investments. This situation contributes, in turn, to Ceará's chronic economic backwardness.

State governments of the Brazilian Northeast are fiscally too powerless to provide remedial action in time of drought. The aggregate product of the region has never been sufficient to generate adequate reserves. It should be borne in mind that Brazilian tax legislation does not delegate any authority to states for autonomous fiscal policies. Taxes, even state taxes, are legislated in Brazil's federal capital, Brasilia, so that, for instance, the rates of the value-added Sales Tax (a tax which provides 90% of all state tax

3 Based on Ronald A. Arraes and Ivan Castelar, "The Effects of Drought on Public Finances in the State of Ceará." In Magalhães and Bezerra Neto, op. cit.

revenues) are determined federally for all states. As a consequence, the amount of taxes collected by the state should be directly dependent on its aggregate product: if that product dropped (as presumably would be the case in drought years), so, too, should state revenue.

This is not true of state expenditures, however, which, prior to empirical studies on the 1970-85 period, have shown not to have been directly linked to economic indicators, and even less to climatic factors such as droughts. This is the main reason for not including state expenditures in this study.

While it is true that state revenue is made up of other components, besides taxes, some of those components show no link to any economic or fiscal variable. Consequently, when tax collections drop as a result of drought, the only available recourse to affected states is to ask the federal government for special increases in its transfer of funds. Success in this endeavor depends on a state government's bargaining power, and/or its consonance with the political orientation of the federal government. In more recent years, the fiscal macroeconomic crisis of the Federal Government has posed an additional difficulty for the raising of federal funds by the states to finance relief programs. The main state revenues are comprised of the value added sales tax (ICMS, in Portuguese) and federal institutional transfer payments.

Institutional transfers consist of specific aliquots (that is, specific tax percentages) of federal tax revenues and, thus, are relatively fixed. Besides institutional transfers, there may also be extraordinary federal transfers which originate from general appropriations for development programs or disaster relief and which are established on an ad hoc basis and, thus, considerably unpredictable. Drought relief actions are financed with extraordinary transfers. In this study, these extraordinary transfers have not been taken into consideration, though they have an important role to play in drought years.

The Basic Assumptions

The basic assumptions underlying this research project are as follows:

a) Government revenues come mainly from tax collections that are dependent on the level of the gross regional or state product. In particular, tax collections increase when the gross product increases. If that product drops, so, too, should state revenues;
b) Drought causes a fall in the farming product and, hence, in total regional product (recall that the proportion of the agricultural product in total regional or state product is about 20% in normal years);
c) Hence, droughts adversely affect public revenues, making it more difficult for state governments to cope with droughts;
d) There are compensatory mechanisms, such as transfers from the federal government and increases in imports, that counter the drop in tax revenues.

Intuitively, the most immediate effect of drought would be on the state's farming sector, as noted earlier. This is where the ravages of drought are often most evident, and also where official relief efforts can most directly have a beneficial impact.

Testing the Hypothesis

To test these hypotheses for the state of Ceará, the classical type of linear regression analysis was used, setting up specific models that cover the triad: Ceará tax collections, the state of the economies (Brazil's and Ceará's), and Ceará's climate. The study period covers the years 1970-85, from which 1970 and 1979-83 were drought years, and 1981-83 were years of national economic recession.

The actual order in which the data were analyzed was as follows:

a) the variation of aggregate sectoral products, for the three component sectors of Ceará's economy (farming, manufacturing, services), as a function of the Gross Product of the National Economy (GNP) and of the presence (or absence) of drought;
b) the variation of state revenues as a function of their two major components, sales tax collections and federal institutional transfer payments;

Photo by Luiz Clementino

Água: poço/Water: well

c) the variation of Ceará's sales-tax collections, as a function of the gross product of the state's service sector and of the presence (or absence) of drought; and the variation of federal institutional transfer payments received by the state.

Results

Interesting results came from this study. As expected, the share of the farming sector in the economy is greatly reduced in drought years, while the share of the services sector is increased. The state's sales tax are explained by the product of the state's services sector. The surprising result was the negative correlation between sales-tax collection and rainfall, i.e., tax collection increases in drought years (in the case of our sample).

Further analysis considered several alternatives for studying the effects on state revenues of both drought and economic recession. The analysis considered three situations: first, the occurrence of recession in Brazil and no drought in Ceará; second, no recession in Brazil and drought in Ceará; and third, no recession in Brazil and no drought in Ceará.

Case 1. **Recession in Brazil, no drought in Ceará.** As expected, this would have resulted in revenues lower than those actually experienced, the ratio of actual/projected ranging between 1.11 (1980) and 1.18 (1982), with an average for the 1981-83 period of 1.15. In other words, had there been recession in Brazil and no drought in the state, Ceará's yearly revenues would have been about 15% lower.

Case 2. **No recession in Brazil, drought in Ceará.** To simulate the non-recession situation, we assumed that the country would have continued to grow at its 1979-80 rate of 4.5% per year in real terms. As a result, revenue in Ceará would have exceeded that actually generated, with the ratios actual/projected ranging from 0.86 (1983) to 0.94 (1981) and averaging 0.90. Thus, had there been no recession in Brazil and a drought had occurred in the state, Ceará's annual revenues would have been about 10.4% more.

Case 3. **No recession in Brazil, no drought in Ceará.** Here, the findings were intermediate between the two previous cases, actual/projected revenue ratios ranging between 0.96 (1983) and

1.05 (1982), with a mean of 1.012. In this case, the State would have suffered an average annual revenue loss of 1.2%.

The following table illustrates the various combinations of effects on the State revenues (as compared to 1981-83, when both recession and drought occurred):

Table 3
Northeast Brazil (State of Ceará)
Relation between State Revenues, Drought in the Northeast and Recession in Brazil
1970-1985

Situation	Drought	No Drought
Recession	-	- 15.0%
No Recession	+ 10.4%	- 1.2%

Accordingly, strictly from the viewpoint of maximizing state revenue in the period studied, Ceará was best off when Brazil's economy boomed but there was a drought in the state. This astonishing result may be explained as follows:

a) a drought causes a fall in agricultural product and hence in total product, but b) it triggers federal government relief actions (not considered in the model) that c) monetize the economy through cash payment of wages and purchase of inputs, so d) stimulating the services sector activity, mainly civil construction (through the work-fronts), the commerce and the import sector, thus e) increasing the base for state tax collection.

The total effect of droughts and relief programs in public revenues can be divided into a) a drought effect, which is negative, andb) a relief action effect, which is positive and whose absolute value is bigger (or at least was bigger in the sample period) than the corresponding value of the drought effect.

Conclusions

These findings indicate that the composition of the state's revenue consists primarily of locally collected, value-added sales tax and of institutional transfers by the federal government. The ratio between these two, and the variation of said ratio from year to year, are shown and analyzed. There is evidence that the two components tend to offset each other, so that total state revenue drops only if both components drop.

The state's sales tax is generated mainly by the Services sector. A calculated regression indicates that tax collection varies directly with the gross product of state Services, but inversely with the occurrence of rains, i.e., tax revenues are higher if there is a drought (and if there is a federally financed relief program). In fact, the gross product of Services itself varies in the same unexpected manner, i.e., it is higher if the state is afflicted by drought.

As far as potential explanations for this state of affairs are concerned (over and above the previously mentioned possibility that the volume of imports during a drought more than makes up for the turnover lost because of it), there is also the effect of monetization. Drought-relief payments are in cash, thus showing up more easily in records than the in-kind payments often used on farms in the interior.

Finally, federal Extraordinary Transfer Payments certainly have a major impact on the situation. However, there are no good data available for these extraordinary transfers, because they are neither budgeted nor scheduled, but rather determined by specific conditions and political and economic injunctions. However, their potential impact can be gauged by the fact that, according to Affonso[4], they amounted to 58% of state tax revenues in 1983.

While the period analyzed was 1970-85, some changes have since occurred in relation to state revenues. The Brazilian 1988 Constitution contributed to some fiscal decentralization from the federal to the state and municipal levels. These changes notwithstanding, they do not affect this analysis because the basic characteristics of the fiscal system remain the same.

In more recent years the fiscal crises of the federal and state governments have worsened. For example, for the first time the Federal Government did not organize and finance a relief program for the 1990 drought. In this specific situation, some conclusions of this study for the earlier period, namely that state revenues go up during droughts, may not apply, because in that instance there was no additional injection of federal expenditures in the state.

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4 J. R. R. Affonso, 1985: "Transferências Intergovernamentais e o Financiamento de Estados e Municípios." *Revista de Finanças Públicas*, N° 363.

Photo by Luiz Clementino

Água: Caminhão pipa/Water: Pipe Truck

Chapter **4**

THE IMPACTS OF DROUGHT ON HEALTH AND NUTRITION[5]

Introduction

There is every reason to believe that droughts would have great influence on levels of health and nutrition, through effects which could be divided into short, medium and long-term phenomena. Such influence would be reflected in the mortality and morbidity rates of the affected population.

Prolonged drought would inevitably result in food scarcity that might lead to malnutrition and, in extreme cases, starvation. While such scarcities might affect both adults and children without distinction, it is among children, particularly very young children, that the most dramatic symptoms would be expected. If appropriate food is not available at the time a breastfed baby must be weaned, the baby's growth will be stunted.

Nutritional deficiencies may predispose children to illnesses of all kinds. Children suffering from acute malnutrition may recover if provided with adequate food, but the effects, such as lower physical and mental development, persist for a long time. Thus, children who recovered from severe protein-calorie malnutrition will feature IQ levels below those predicted for well-nourished children of the same socioeconomic level. What is more, they will develop symptoms of poor working capacity in adult life. Babies born to poorly nourished mothers, during periods of intense hunger, run a very high risk of being underweight.

5 Based on Marcelo Gurgel Carlos da Silva, "Effects of Drought on Health and Nutrition in Brazil's Northeast." In Magalhães and Bezerra Neto, op. cit.

Material and Methods

The basic material used by the author in this report originated either from data published by the Brazilian Ministry of Health, or from special tabulations. Data refer to the semiarid Northeast, comprising the states of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Sergipe, Alagoas and Bahia. The data were critiqued and unreliable data were discarded.

For the present study, the author selected 19 causes of death. Some of them, e.g., gastroenteritis, pneumonia and malnutrition, are easily affected by climatic variability on a variety of time scales. Secular trends were analyzed from 1977 to 1984, as well as by comparing the drought period (1979-83) with a pre-drought period (1977-78) and with a post-drought year (1984).

In order to diagnose and analyze the health status in the drought-affected area for the 1977-84 period, the following health indicators were selected: crude mortality, proportional mortality ratio, proportional mortality curve, Guedes' index, proportional mortality cause, and child mortality. The proportional mortality curves, or Nelson de Moraes curves, graphically portray the distribution of proportional mortality in the following age groups: less than 1 year old; 1-4 years; 20-49 years; and older than 50 years. The Guedes' index is a measure of the proportional mortality-curve data.

Findings

In the 1977-84 period, there was an increase in mortality rates in the Northeast, from 4.7% in 1977 to 6.3% in 1984, representing an additional risk of 50.6%. The mean annual number of deaths was 125,746; in the five years of drought, the mean increased by 45,9%, with most of the increase occurring in the semiarid interior. However, the author found no reason to attribute this additional risk to the drought.

Indeed, the percentage distribution of deaths by specific age groups, in the proportional-mortality curves, characterizes a low health standard for the first few years in the series, followed by a transition to a reasonable health level at the end of the period. Even during the 1979-83 drought period, the data for proportional child mortality all coincide in characterizing improved health levels.

How can one reconcile increased mortality risk with improved health standards? This is not an easy question and certainly deserves further research. The author explains that the percentage of drought-related death causes, such as gastroenteritis, pulmonary tuberculosis, pneumonia, etc., went down, while other causes not drought-related (such as ischemic heart disease, cerebrovascular disease, and accidental drowning) went up. The risk of intestinal disease dropped by one-half. Mortality due to nutritional deficiencies and to anemia generally remained stable up to 1980, when it started a 3-year decline which was again reversed in 1984.

This general pattern was identified, when studying the Northeast as a whole. The author used a sample of 3 states where data were found to be more confident (i.e., Paraíba, Pernambuco and Alagoas) and a sample of 25 "*municipios*" (counties) selected for their consistent availability of data and low rate of unreported deaths. Also in this latter case, the findings indicate a clear improvement in prevailing health conditions. Given the fact that the series only covers 6 years, it is nonetheless possible to see a reduction in the risks of intestinal diseases, immuno-preventable diseases, pulmonary tuberculosis and increases in ischemic heart diseases and perinatal disorders.

In the Northeast as a whole, the child mortality rate which was 104.3 (per 1000) in 1977 dropped yearly, reaching its lowest value in 1982 (65.8), after which it started to climb again to 73.7 in 1984. The phenomenon occurred for both infant and preschooler mortality (but particularly the latter) as well as in all regions of Brazil. Nonetheless, the deterioration in this rate was especially sharp in the Northeast. Indeed, when studying the causes of child mortality, one finds that the risk differential is about three times as great in the Northeast than in other parts of the country.

The risk of nutritional deficiencies rose from 1977 to 1982, when it reached a plateau, after which it decreased in 1983, only to rise again, almost doubling in 1984. Could that be considered a delayed consequence of the extreme drought situation in 1983?

Discussion

The findings of this study are, in principle, surprising. In the course of the time series (albeit short) there occurred a gradual shift in mortality towards a more advanced age; thus, the proportion of infant and preschooler deaths declined year by year, while the share of deaths among older people went up. While the configuration of the proportional mortality curves is typical of a population's low level of health, there is at the end of the surveyed period a clear suggestion of transition towards a reasonable level.

Although the data suggest a favorable secular trend, the most recent indices are far from satisfactory, particularly when compared to those of industrialized countries. Thus, the mortality rates for preventable diseases are still very high.

A cause for concern is the alarming proportion of mortality for ill-defined causes. Some 45% of the deaths in the Northeast were attributed to ill-defined causes, particularly in the interior, where this category reached 60% of the total. Concern about this problem is justified because it suggests that death occurred in the absence of any medical attention. These people do not receive adequate health care, even in the time of fatal illnesses.

On the other hand, the pattern of occurrence and distribution of deaths in the absence of medical care is very similar to that for deaths due to gastroenteritis and pneumonia. This situation provides circumstantial evidence for the assumption that the coefficients for these two factors are grossly underestimated, aggregated as they are under the "ill-defined causes" heading. Thus, they are probably very much influenced by drought.

Another obstacle to a precise determination of the Northeast's health status is the high level of unrecorded deaths, especially in the interior. Such lack of registration is by and large inversely proportional to the age at death, and is much more likely to occur in the case of children than of adults. This constitutes circumstantial evidence in support of the theory that infectious diseases, considerably more prevalent in childhood, are much more often left unrecorded (and hence underrepresented) than other causes of death.

As for malnutrition, detection using death certificates is of limited value. Malnutrition is often omitted as a cause of death. If the analysis were to have been carried out using the multiple-cause technique, the malnutrition coefficient would have been much higher. Nonetheless, a community's state of malnutrition can be gauged by other, indirect, means such as preschooler mortality, infant mortality, and mortality due to gastroenteritis, measles, and pneumonia. These indirect indicators show that malnutrition is highly prevalent and a serious public-health problem in the Brazilian Northeast, even if its trend at present appears to be downward.

Specifically from the viewpoint of comparisons between the drought, pre-drought and post-drought periods, the drought showed no negative effect on the upward course of key health indicators. By the same token, the profile of causes of mortality, characterized by declines in infectious diseases and by increases in coronary diseases and homicides, was maintained during the 5 years of drought. Even the proportion of nutritional deficiencies recorded during the drought is below that of the two adjacent periods.

The most surprising finding of this study, that the frequency of malnutrition actually increased after the drought, merits further investigation. At this point, it seems reasonable to postulate that environmental or climatic factors, like droughts, do not necessarily play a major direct role in the social determination of malnutrition, and that socioeconomic conditions may be of more importance. For instance, statistics show that an infant is twice as likely to die during its first year of life in the Northeast than in the rest of Brazil. Indeed, the income of the poor has obvious consequences for their food intake and their welfare in general.

Some Limitations of the Study

Before one accepts these findings without question, it is important to remind the reader that there are some obvious limitations to this study. First, it is based on mortality data, whereas morbidity data would have been more sensitive in detecting the effects of droughts. Nevertheless, mortality is a crude measure, however indirect, of morbidity.

A second limitation relates to the fact that this study did not take into account the progressive aging of the population, variations in medical care, health-care expenditures, competitive risks among diseases, and the episodic nature of some diseases.

A third limitation relates to available statistics. The length of the time series could not be extended backwards because of the earlier lack of a standardized system for reporting mortality figures. By the same token, data more recent than 1984 had not as yet been published at the time of this study. Yet another major shortcoming with respect to data is the high proportion of mortality for ill-defined causes and the likely lack of recordings of infectious diseases.

Concluding Remarks

The existence of greater federal funding for the Northeast, through drought relief programs, is important. Because a large fraction of such federal transfer payments consists of cash paid out as relief salaries for the drought-stricken poor, this changes the archaic production relationships that prevail in the rural areas (before, such relationships had for the most part been based on payments in kind). By so monetizing the local economy, these funds not only raise the real income of rural workers, but also provide a greater number of purchase options. As a result, the drought indirectly and unexpectedly may actually contribute to improving the health level of this population.

The unexpected results of this study, and the shortcomings of the available statistics, as well as of some specific characteristics of the methodology that were used (for instance, emphasizing the proportional analysis and, to some extent, not searching for explanations about the quantitative increase in total mortality), underscore the need for further investigation. By now, there is enough evidence that societal and governmental responses to drought in the Brazilian Northeast have been able to cope with the immediate impacts of droughts on the population's health, while structural socioeconomic factors that characterize underdevelopment everywhere still predominate.

Chapter 5

POLITICAL IMPACTS OF DROUGHTS[6]

Introduction

There are several ways of looking at the droughts in the Brazilian Northeast, several of which have been adopted in various parts of this UNEP/SEPLAN Project. In this chapter, the author describes how drought affects the region's political situation.

The advent of drought acts as a proverbial curtain raiser, exposing to a largely uncomprehending public a dynamic situation of what, before the drought, seemed to be a static and hidden situation. Here, the nature of rural society is described, as are the various stages of what happens when a drought occurs.

Drought disturbs the status quo. On the one hand, it reinforces traditional and archaic social relations. On the other, however, it plants seeds that ultimately perturb these very same archaic relations. The main elements of such social relations stem from the regional land tenure system. For example, land ownership is highly concentrated, with large holdings on which the landowner raises his own cattle while crops are grown by share-croppers.

The rural population — poor and illiterate, with large families — are totally dependent on the landowner. They live and exist by his grace since, otherwise, they have no viable alternative except to migrate to urban peripheries, only to end up joining the ranks of the impoverished urban unemployed.

Given such circumstances, it is not difficult to see why the rural poor tend to follow the landowner's wishes in all respects, whether this means how to vote or when to apply armed force. He is the boss,

6 Based on César Barreira, "Drought: Power and Survival." In Magalhães and Bezerra Neto, op. cit.

occupationally and politically. There is, in addition, a strong cultural factor: the boss represents tradition, protection, a stern and sometimes unjust authority, but nonetheless a father figure.

Besides the poor rural population (in fact, the majority of the population) and the landowners, the local power structure includes local town authorities: the prefeito (the county executive), the judge, the vicar, the police commissioner, and politicians at all levels, federal authorities, military, financial and other institutions, and the banks.

When Drought Comes

The agricultural production process is immediately interrupted when drought strikes. There is widespread unemployment and penury among the sharecroppers and farm workers. For the landowner, problems exist but they are much less serious. For a while, the cattle can continue to graze the scrubs and the water holes continue to produce for some time. Generally, the owner has stored some reserves of water and fodder, in addition to financial reserves. During extreme drought events, the owner has the option of driving his herds to greener pastures.

Farmworkers, sharecroppers and even small farmers in the semiarid area, threatened by food shortages and possible hunger, start their search for relief. As "scourges," they invade towns and loot warehouses. What they primarily seek is work. Only if that search for a job is to no avail do they go in search of food. The following excerpts from a local newspaper (O Povo) in Ceará, during the great drought of 1958, provide examples of this escalation in desperation.

- Every day dozens of families fleeing the ravages of drought arrive in this capital. Having given up all hope of rain, they come here to ask the authorities for help to survive (Fortaleza, 17 March 1958)
- In this municipality, hungry crowds today broke into the prefeito's house, looking for work (24 March 1958)
- Eight thousand hungry people attacked local stores looking for food; they concentrated on food warehouses and meat markets. Some of them had not eaten for 20 hours (8 April 1958)

The Role of Government

Landowners, as well as town authorities, transfer the problem to state and federal authorities. Considering the limited resources available to state governments, the federal government has in the past stepped in to assist. Federal relief funds begin to flow, and things begin to improve; a lot for some, much less for others.

Depending on the way that federal funding occurs, there may be more or less political impact of the drought. With the federal government in the picture, a number of opportunities open up. For example, road and dam construction, and even improvements on private farms, may be undertaken through the payment of wages to farmworkers and the acquisition of inputs with the federal funds. Consider the possibilities for politicians. First, there is the target of government (or political) action; what is being built and where, for whom is it being built, and by whom. Friends can be rewarded and enemies can be punished. There is money to be earned. Nevertheless, legitimate community wishes can also be met.

The Political Aspect

There is a direct and obvious political aspect of emergency relief. The drought and its emergency relief efforts are useful in electoral campaigns. Entire elections have been won (or lost), depending on the strength of regional drought-relief works. The federal government has been aware of this situation, and has signified its intention to help during drought events, particularly through its political allies in the respective Northeastern states.

The Process for Government Action

While farmworkers' needs and frustrations escalate, first gathering in the streets, then occupying government buildings and, finally, looting food stores, none of the sides (the looters, as well as the looted, or the authorities) takes an unduly harsh view of these farmworkers' reactions. In fact, there is something almost ritualistic in this spectacle. Only the federal authorities have the financial resources with which to help, and they only step in if the state authorities raise an outcry, and such outcries are often produced by looting.

Thus, everyone is involved. For example, everyone knows that, once federal funds start to flow, the benefits will be spread around, the wealth will be shared and, last and least, the hungry will be fed. So, everyone does his part — knowing well that later there will be mutual recriminations and accusations about the misuse of funds and about illicit enrichment. Investigations will follow but nothing will come of them. For their part, the poor loot and the police look on; society understands. Everyone agrees the action is justified for, ultimately, everyone gets a piece of the action.

When the Rain Comes

When the drought comes to an end and the rainy season arrives, landowners go back to business and farmworkers go back to work. The pre-drought power structure remains preserved. Farm infrastructures have been improved by public works, the federal government has made farm loans and forgiven debts, merchants have made profits, politicians have won elections. The landowner is once again hiring.

A new winter is in the offing, bearing a promise of rains. The looting has been forgotten and forgiven — after all, farmworkers are not bad people, they just insist on staying alive (and well they should — they are needed to tend the farms once the drought has passed).

Basic Intentions

What does all this mean? It means that farmworkers have been the proverbial "pawns" in the great drought game — the ones who paid the most while those around them were getting theirs. It means that the local structure and higher levels of government worked hand in hand, ostensibly to improve their lot, but actually to strengthen the existing, anachronistic social structure.

It also means that the basic intentions of the local elites in relation to the farmworkers were to keep them on the farm, because they would be needed when the drought ended; keep them out of town, alive and quiet. In other words: to keep everything as is, once the drought emergency has passed.

Winds of Change

In this chapter, we focused on typical droughts of the past, especially the major one of 1958. However, much of what has been said is applicable to 1970 and even 1983. It must be recognized, nevertheless, that there have been changes both in society and in government behavior. Some new approaches have been tried, some new participants have gotten into the act... and the country, too, has been changing. For example, new participants have appeared on the scene: the churches, farmworkers unions, more militant farmworkers' women, and new democratic political organizations. There are signs that things are changing for the better. The experience of the 1987 drought, as described in one of the next chapters, a significant attempt to break from the entrenched traditional societal responses to drought.

Carroça transportando água/Cart carrying water

Chapter **6**

METHODOLOGICAL CONTRIBUTIONS TOWARD SOCIETAL DROUGHT MANAGEMENT PRACTICES[7]

Introduction

This study attempts to set forth some methodological conditions for assessing drought in an economically developing and overpopulated region. It views drought over and above its physical impacts, as a societal phenomenon. Although recognizing that the physical dimensions of drought are important, seeing drought as a social phenomenon in a developing region can be justified by a number of arguments, such as the following:

a) human actions reinforce the adverse consequences of drought, such as deforestation, depletion of water resources and misuse of water supplies;
b) there is a societal origin of human behavior towards drought, such as the "drought industry" (indústria da seca) or the drought culture;
c) governmental action in response to drought is a socio-political phenomenon;
d) also societal in its origin is a type of scientific or technical attitude with a biased approach that concentrates attention and, therefore, responses on only one aspect of the situation, either physical or social;
e) there is a need for a societal viewpoint seeking to define the problem from the people's perspective, so that its physical and human dimensions are combined;

7 Based on Pedro Demo, "Methodological Contributions towords Societal Drought Management Practices." In Magalhães and Bezerra Neto, op. cit.

f) anthropogenic activities are creating the conditions for the occurrence of the greenhouse effect and future climatic change, thereby altering the frequency, intensity, duration and location of future droughts as well as other climatic phenomena.

The motivation behind this study is to design methodological approaches capable of defining an attack on the structural components built into present-day drought situations, as well as future drought situations that might result from global warming.

The Social Sciences Focus

The most methodologically balanced position to deal with present and future droughts is the one defined as historical-structural, one which combines both objective and subjective aspects. Objective conditions are those factors that are exogenous to human agents. Subjective conditions encompass the "manmade" range of human actions.

There appears to be given circumstances that condition society's historical actions. Yet, the approach stresses the importance of the individual as an actor.

However, history is neither entirely "made" nor just passively accepted. We are, in part, the product of our physical and social environments, and in part we create our own history.

When we talk of "alternative methodologies" to deal with drought, we do so in an effort to transcend positions excessively imbued by the ethos of the natural sciences, in which only objective factors are relevant. Social reality is different from natural reality, since it contains subjective condition components such as ideology. Social reality is always political.

In this framework, sharp differences may emerge between the classical methodologies that only assess, research, and systematize and those others that seek to establish a direct link between study and action. Thus, poverty, like droughts, is studied not only in order to understand it, but also to combat it.

Alternative methodologies evolve into proposals of participatory knowledge generation, participatory research, qualitative assessments, and action-oriented research, e.g., phenomenological research methods in which diagnoses become self-diagnoses and planning becomes self-planning. Without detriment to the objective, quantifiable side of social reality, the emphasis is on the potential space for historical conquest, for instance, how to overcome the impacts of present and future droughts, elevating people from the level of objects of manipulation to that of subjects of their own destiny.

Social reality is also quantitative, so the quantitative method is normally quite appropriate and very distinct from empiricism. No participatory research could dispense with formal and measurable facts. Thus, the need for complementarity is undeniable.

Alternative methodologies may be advisable, because we are seeking to identify the most appropriate treatment for the political facet of drought: trying to view the drought-stricken not as victim, but as someone capable of reacting with creativity, provided that the individual in question develops his or her political status.

Drought as a Physical Condition

Rain falls, not because people will it, but for physical reasons. Thus, it makes little sense to reduce drought to a mere social matter. It is important to note the methodological tools involved in treating this type of occurrence, drought, precisely because it is quantitative. There are problems of quantification, but these can be attributed solely to technical limitations. This characteristic of drought is a methodological advantage, because it fits neatly within the expectations of the natural sciences and the methods with which they are familiar. However, when it comes to social reality and its qualitative aspects, this no longer holds true. Drought, when viewed solely as a physical condition, can lead to inadequate policy answers. If the social aspect is omitted from assessments of drought, technical solutions can easily be nullified.

Drought as a Political Phenomenon

Two dimensions of drought as a political phenomenon are known in Northeast Brazil:

a) the "drought industry" (composed of powerful groups that benefit from drought by preying upon the drought-stricken poor and by diverting for their own profit the aid destined for the poor) characterizes the presence of subjective conditions;
b) the drought culture is the core around which an historical identity congeals, with people internalizing a certain kind of conformist expectancy which they integrate into their framework of fundamental values. For example, the physical shortage of water takes on the nature of an inescapable fate.

What particularly exacerbates the situation is not that the population submits easily to drought as a physical phenomenon, but that it so easily submits to the drought industry.

It is certainly impressive that the Northeast combines Brazil's greatest agglomeration of poor people with its strongest redoubt of political conservatism. In any event, it disproves the theory that the poorest are the most revolutionary. Historical experience in the region seems to point precisely the other way.

Thus, dealing with drought often becomes a lost cause for technicians who identify the physical constraints and the reasonable chances of reversing them, but who do not know how to address the political aspects of drought problems.

Actions: Opportunities and Limits

In addition to socioeconomic poverty, there is political poverty, characterized by pawn-like electorates, marginal citizenship, at-will manipulations of vulnerable groups by other groups of the population. In their social aspect, droughts have much to do with political poverty.

Droughts cause inconveniences but also advantages. They are able to transform physical necessity into political profit, mostly by taking advantage of the political poverty of the needy.

Alternative, qualitative methodologies seek to open avenues for treating this syndrome, through the following points:

(1) recognizing that it no longer suffices to know about droughts only for knowledge's sake;

(2) nothing is to be served by downgrading theory, but it is nonetheless imperative that we either learn to investigate drought and poverty in order to offer solutions, or else admit that our real aim is to evade the issue;
(3) we must move on to the matter of qualitative strategies for the treatment of political poverty. It is necessary to generate a type of knowledge that manages to raise the consciousness of the poor until they become the target of the development process;
(4) qualitative evaluation of such processes, especially the difficulties in state-to-people relationships. There arises the dimension of political quality. On the horizon of policy makers, there looms the figure of the citizen as the political actor in the development process;
(5) such a methodological posture requires, with the affected population, a relationship of familiarity, shared experience and, at the most advanced stage, of ideological identity.

As a final comment, the age-old image of the drought victim must be overcome.

Preliminary Requirements

For coping with present and future droughts in a preventive manner with respect to societal impacts, some preliminary requirements can be visualized. Long-range and short-range requirements should be differentiated. Active citizenship demands an extended preparation over time, a process that is basically open-ended.

The formation of popular citizenship requires some steps to be followed: a) society must be organized; b) elementary school must be universal; c) a cultural identity must be fostered; d) certain rights must be won in the struggle for institutionalized rules-of-the-game; and e) a quality public service must be attained.

Some measures are as follows:

On the Governmental Level

a) develop well-planned preventive strategies; b) set up structural projects; c) keep out the drought industry and dismantle the drought culture; and d) introduce drought-resistant crops and irrigation projects.

On the Population Level

a) work actively on popular organizations; and b) insist on the participation of the vulnerable population in any public system of drought management.

Summary Comments

Alternative methodologies consider method to be simply an instrument, placed at the service of matters considered relevant. First, there is the reality whose theoretical and practical treatment represents the scientific objective. Then comes the method. One must insist on combining theory and practice, because the goal is not observational "data" alone, but scientifically grounded responses to the drought problem, whether present droughts or the future regional consequences of global climate change.

Chapter 7

GOVERNMENT STRATEGIES IN RESPONSE TO CLIMATIC VARIATIONS[8]

Introduction

What lessons can we learn from the Brazilian experience in the field of drought relief and how can we use such experience in the event of a climate change? This study begins with a brief history of Brazil's organizational efforts for coping with drought. Then we focus on specific drought responses in 1987 and end with a discussion of objective lessons derived from that experience, to be utilized in improving future policy responses.

Historical Background

The development of drought policy in Brazil began after the great drought of 1877, when a disaster of enormous human and economic dimensions took place. In more than one hundred years, the development of drought policy experienced the following phases, as determined by its predominant characteristics:

a) the study phase: 1877-1906
b) the engineering and water resources phase: 1906-1945
c) the ecological phase: 1945-1950
d) the economic development phase: 1950-1970
e) the socioeconomic development phase: 1970-1990
f) the sustainable development phase: 1990-

8 Based on A. R. Magalhães, J. R. A. Vale, A. B. Peixoto, and A. P. F. Ramos, "Governmental Strategies in Response to Climatic Variations: Drought in Northeast Brazil." In Magalhães and Bezerra Neto, op. cit.

There is no distinct separation between the phases. Also, a new phase does not necessarily replace the previous one. Rather, it incorporates new elements that eventually become predominant. In this sense, the drought policy in Northeast Brazil evolves with time and becomes more complex and integrated.

The Study Phase (1877-1906)

This phase is characterized by a series of reports and a few extemporaneous actions. After the 1877 drought, a National Commission of Inquiry established by the Emperor of Brazil studied the drought problem and recommended the construction of water reservoirs, the drilling of wells, and the construction of canals, roads and ports.

Between 1904-1906, three more technical study groups visited the Northeast and wrote reports with similar recommendations. With respect to policy during extreme droughts, some limited drought relief action was tried, consisting mainly of food distribution, with almost no results. There have been incentives for people to move to the Amazon, to work as rubber tappers. Much before that, in 1859, one extemporaneous response that now belongs to regional folklore, attempted to bring and adapt African camels to the semiarid region of the Northeast. Needless to say, it was a complete failure.

The Water Resources/Infrastructure Phase (1906-1945)

In 1909, a permanent institution — the Superintendency for Studies and Drought Relief Works — was created, charged with the problem of Northeast droughts. By that time, the Cedro Dam, the first big dam for water storage, was inaugurated in the state of Ceará.

The new Superintendency went through a number of name changes, but since 1945 has been known by its present designation: National Department for Drought-Relief Works (DNOCS, in Portuguese). During this phase, the emphasis was put on building a water-supply infrastructure that today stores more than 22 billion cubic meters of water. However, there was no corresponding provision for the large-scale use of the stored water for farm production activities and irrigation.

The Ecological Phase (1945-1950)

During this phase, there was an effort to implement a strategy to strengthen farm production by way of the introduction of drought resistant crops. Agriculture was to be adapted to the ecological conditions of the semiarid region. Farmers were advised to plant hardy varieties of cotton feed crops among other species.

The Economic Development Phase (1950-1970)

Following the trends of industrial development of Brazil, there was, in the 1950s, a widespread conviction that, in order to reduce regional disruptions by droughts, a strong agricultural sector had to be complemented by industrial development. With the advent of abundant power produced by the new São Francisco River Power Company (CHESF), industrial development in the Northeast became a real possibility.

This phase also witnessed the creation of the São Francisco Valley Development Company (CODEVASF), the development Bank of the Northeast of Brazil (BNB) and the Superintendency for the Development of the Northeast (SUDENE). SUDENE's mission, based on proposals contained in a plan of action called "A Policy for the Development of the Northeast" (SUDENE, Recife, 1967, 2nd ed), encompassed the following objectives:

a) to promote industrialization;
b) to stimulate food production in the region's coastal and humid areas;
c) to restructure the economy of the semiarid regions by promoting adaptive farming; and
d) to take advantage of the region's as-yet-unopened frontier areas, via land-settlement projects.

SUDENE operated through Northeast development plans approved by the Brazilian Congress. In short order, SUDENE became the region's paramount development agency, particularly

Açude do Cedro/Cedro Dam (Quixadá – Ceará) through a financing mechanism not originally envisaged, based on fiscal incentives to private enterprises (called Fund for Northeast Investment - FINOR). Thousands of private projects have since been implemented through FINOR.

After 1964, a new federal policy reduced SUDENE to a shadow of its former self. Regional plans were replaced by mere chapters in the National Development Plans. But FINOR remained as a financing mechanism supported by a powerful constituency among Brazil's conservative business community.

In 1970, a major drought forced government to take another look at the Northeast problem. The following new priorities were set:

a) the integration of the Northeast into the national economy, including into the Amazon region; and

b) public irrigation.

The over-ambitious Transamazonian Highway was built in part to stimulate migration from the Northeast to the Amazon, and irrigation projects were implemented in the Northeast to foster production and employment for those who decided not to migrate.

The Socioeconomic Development Phase (1970-1990)

During the first half of the 1970s, another dimension was added to government and societal perception of the drought phenomenon. It was realized that, in order to cope with droughts, attention had to be paid — over and above meteorological, "ecological", economic and developmental factors — to the region's glaring social problems. As before, this realization did not occur in a vacuum, but was part of the prevailing *Zeitgeist* that led the World Bank, for instance, to define poverty eradication as a priority.

The policy response to this enhanced dimension of Northeast drought was not the usual creation or adaptation of institutions, but the establishment of integrated rural development strategies through projects to be executed by existing institutions. Several projects have been designed and executed in the last two decades. In the 1980s, a comprehensive integrated strategy, named Project Northeast (Projeto Nordeste), was designed and implemented as a regional socio-economic development strategy.

The Sustainable Development Phase (1990-   )

At this point in time, a new dimension is being introduced in perceptions and hopefully in policy responses: the environmental aspect. Different from the ecological phase, where plant adaptation was the focus, environmental concern now involves a broader set of environmental considerations. It is now recognized that past development actions have been undertaken to the detriment of natural resources and of future generations. Sustainable socioeconomic-ecological development is now advocated as the proper answer to reduce the vulnerability of the Northeast population to future droughts.

The adoption of sustainable development strategies, although accepted as a political and social necessity, poses a challenge to policy makers and to society, since it is greatly dependent on non-existing or non-available technologies and financing. The proper conceptualization of sustainable development is still too incomplete to serve as a guide for regional development planning.

The Emergencies during Droughts

Besides long-term development strategies aimed at permanently increasing the resilience of populations to drought, there is also a long history of emergency relief responses during droughts. The traditional response has been focused on providing jobs — as in an economic Keynesian strategy — to the millions of rural workers and small farmers whose income has been completely cut off by the droughts.

Such emergency action has been provided through the National Civil Defense System, headed in Brasilia by the then-Ministry of the Interior (now the Ministry of Social Action), with regional coordination by SUDENE and state coordination by the State Civil Defense System.

Throughout the decades, the tendency has been to intermingle permanent action projects with ad hoc emergency efforts. As the years went by, the two types of programs tended to grow farther apart, even competing for the same human and financial resources. A movement to review both types of action is now in progress.

The Main Conclusions

1. Drought policy in Northeast Brazil responds to societal and governmental perceptions about the drought phenomena.
2. Each new phase in the series of drought response strategies noted at the outset represents a new dimension in the perception of droughts, which evolved from a simple concern about water shortages to a complex range of meteorological-economical-environmental interconnected variables.
3. The drought problem in a developing region like the Northeast cannot be addressed in isolation from the issue of regional sustainable development. The only way that present and future populations may be made less vulnerable to droughts or other types of climatic variability, including those resulting from a possible climate change, is to ensure economic viability under an environmentally sustained basis, even for the lowest strata.
4. Government policies have been frustrated, in part, by the following factors:

a) the lack of coordination and/or mutual reinforcement between emergencydrought relief and long-term development projects;
b) the lack of continuity in efforts once droughts have ended;
c) institutional instability in relation to the availability of means to combat droughts;
d) the interests perceived as conflicting, between the government (as influenced by the Northeast's ruling elites) and the vast majority of the region's vulnerable population;
e) on many occasions, a phenomenon called "drought industry" has been observed, especially during emergency-relief activities, when influential groups of the ruling elite have managed to divert legally or illegally for their own benefit (through patronage, pork-barrel and paternalism), the activities originally designed to attend to the needs of the poor and vulnerable populations.

Photo by Luiz Clementino

Irrigação no Semi-árido/Semiarid Irrigation

The 1987 Drought Relief Experience

Drought emergency relief programs have generally aimed at:

a) generating a flow of income for individuals deprived of their livelihood by drought, through the creation of Keynesian jobs;

b) assuring the availability of water for human consumption;

c) assuring the availability of food.

During the 1987 drought, the state of Ceará, 93% of which is comprised of semiarid land, designed and implemented a strategy where the main concern was to apply the lessons of experience and to avoid the errors of the past. The program assumed the following characteristics:

a) the reordering of priorities, with prime emphasis placed on projects that would provide immediate public benefits, chosen by the communities involved and consonant with long-range plans and programs;

b) it focused specifically on the vulnerable target population most in need of development aid;

c) the use of emergency action to achieve long-term goals of the state development plan;

d) an avoidance of any manifestation of the "drought industry" and of political manipulation;

e) to ensure effective community participation, according to public criteria, in the selection of beneficiaries, of work projects and in the supervision of their execution, through community action groups;

f) the payment of a "fair" market wage, and insistence on a fair work journey (44 hours per week).

All the state government organizations have been involved in the planning and execution of the program, including the Governor and State Secretaries. An interagency coordinating group has been established to ensure interagency technical coordination.

For the first time ever, communities were given a voice in the operation of the Emergency Program, from its very beginning. Besides increasing cost-effectiveness, this was an efficient mechanism to avert the development of a drought industry. The results have been highly positive, with the construction of thousands of physical improvements for the benefit of the population. Moreover, migration rates did not increase during drought, and health and nutrition indicators did not worsen.

Main Lessons from the 1987 Experience

Two main problems arose: one was funding deficiency. The dependence of the program on the Federal Budget and the fiscal crisis that, due to economic recession, affected the revenues of both the federal and state governments have posed a threat on the capacity of the public sector to provide the necessary financing. The second problem was institutional deficiencies. Emergency actions exert a pressure on the day-to-day activities of governmental structures and, thus, cannot be easily carried out by administrative entities designed and organized to provide routine services, unless relief actions are considered in the context of long-range planning. In 1987, however, integration of temporary relief and long-term development objectives was partially achieved.

The operation of the Community Action Groups was a success. In addition to providing an effective tool for local project management, it also constituted an enriching experience and a step forward on the path of the rural poor toward full exercise of their citizenship rights — and duties. In 1987, however, integration of temporary relief and long-term development objectives was only partially achieved.

PART II

DROUGHTS, FLOODS AND FREEZES IN BRAZIL


Photo by Luiz Clementino

Cerrado

Chapter 8

THE EFFECT OF "VERANICO" DRY SPELLS ON AGRICULTURE IN BRAZIL'S MIDWEST[9]

Introduction

This study investigates the impacts of climatic variability on agriculture in the cerrados (savanna-type) region of Brazil's Midwest (Figure 4). A better knowledge of present climatic impacts will, by analogy, provide society and government with useful information for improving coping mechanisms to deal with the impacts of climate variability and for the designing of policies to face the regional consequences of a possible future climatic change.

Rainfall as well as rainy season dry spells (called *veranicos*) were studied over a long period of time, with particular emphasis on events during the critical rainy months of January and February. In order to evaluate the impact of the dry spells on yields, rice and corn crops were investigated. They were selected because both are sensitive to dry spells and both are important crops in the region.

The economic and statistical analyses covered two types of data, experimental results and aggregate data for the state and region. By comparing actual results with yield estimates based on different sets of climatic conditions, potential losses caused by climatic factors were computed.

The study's findings suggest that it is not necessarily the volume of rainfall but its distribution during critical periods that has the greatest effect on crop yields. There is also evidence that significant losses have been sustained as a result of *veranicos*, such as the 280,000 tons of rice and the 150,000 tons of corn estimated to have been lost

9 Based on Túlio Barbosa and Elmar Wagner, "The Effect of 'Veranico' Dry Spells on Agriculture in Brazil's Midwest." In Magalhães and Bezerra Neto, op. cit.

in 1971. The study discusses some of the strategies available to farmers and policymakers, in order to prevent, minimize, or mitigate the damaging effects of dry spells.

The Region

Brazil's Midwestern (or West Central) region belongs almost entirely to the so-called *cerrados* ecosystem, distinguished by savanna-type vegetation covering large parts of the country's Central Highlands (Planalto Central) — increasingly planted to soybeans, rice and corn — as well as less fertile parts in the Northeast.

The climate of the *cerrados* is tropical rainy in the lowlands and temperate rainy with a dry winter on the central plateau. This area, which extends between 5 - 20S and 45-60W, thus features two distinct seasons: a dry season almost devoid of rainfall from May to September, and a rainy season from October to April. Fundamentally, the dry season is caused by the combined effects of the Antarctic Polar Front, the Atlantic High Pressure Front, and the Equatorial Front.

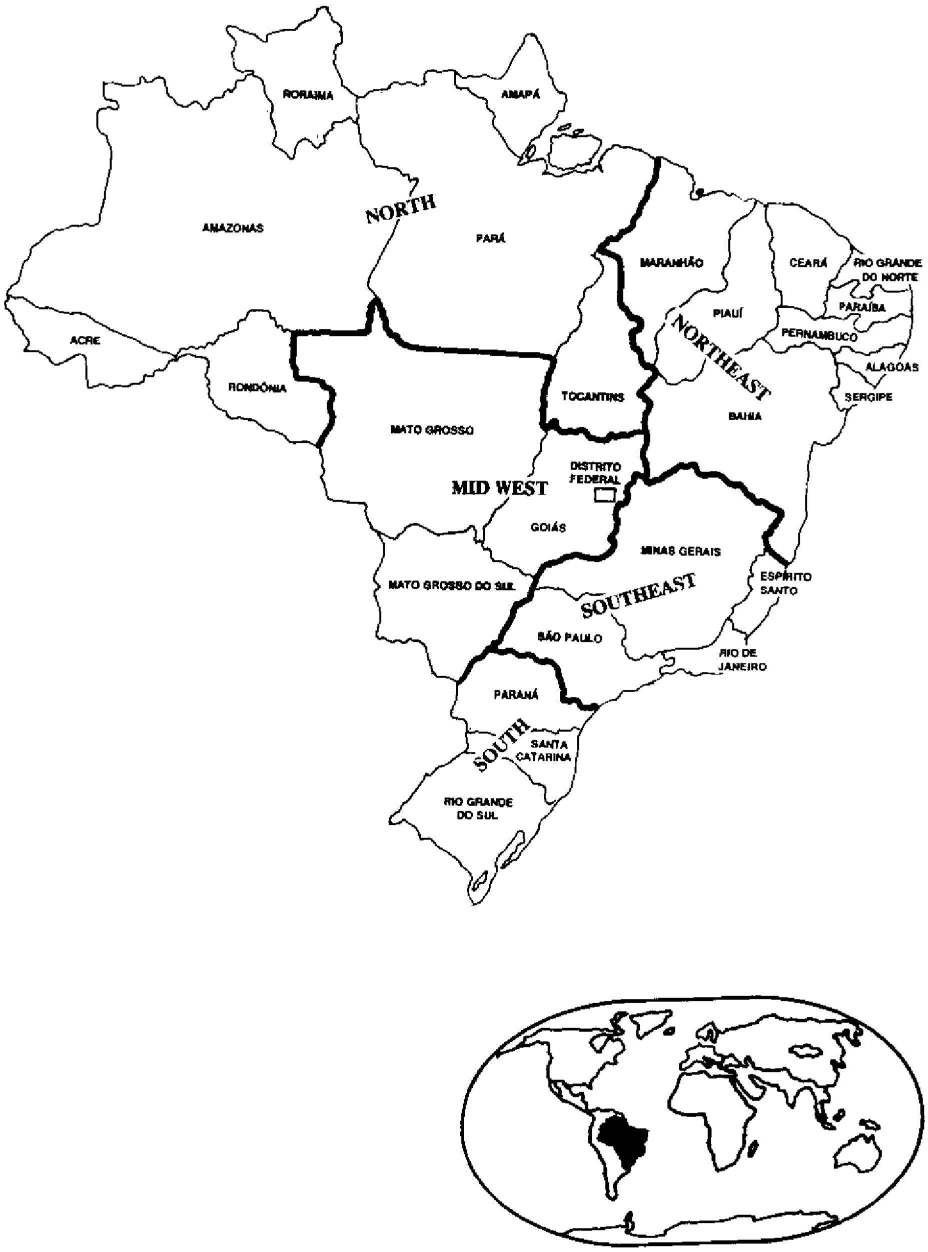
The rainy season is the growing season for crops that are neither subject to photoperiodism nor require minimum temperatures averaging less than 15°C, e.g., upland non-irrigated rice and corn. However, the dry spells that occasionally interrupt the rainy season can cause losses of up to 40%, if they coincide with the time of critical crop development.

Temperatures and Rains in the Cerrados

The climate of the *cerrados* is fairly typical and mostly uniform over its entire area, although close to its borders it begins to transform into the climatic characteristics of neighboring regions. Two outstanding characteristics are (a) an annual rainfall of 1,200-1,800 mm, and (b) a 5- to 6-month dry season.

Actually, over almost two-thirds of the region the average annual rainfall is 1,200-1,600 mm. As far as the dry season is concerned, its duration follows a quasi-normal distribution averaging 5-6 months, but ranging from a minimum of 3 months in the Amazonian region to a maximum of 7-8 months in the *caatinga*

FIGURE 4 - Distribution of Cerrados in Brazil.



brushland of the Northeast. 90% of the territory falls within the 4-7 months range. Temperatures average around 22°C in the South (where the land is at higher elevations — 900 to 1,200 meters) and 27°C in the North. Generally, there are no sharp variations in temperatures: the difference between maxima and minima averages 4-5°C (more in the South, less in the North).

An outstanding climatic characteristic, however, is the occurrence of interruptions during the rain season, the *veranicos*. With respect to *veranicos*, the state of Goiás is typical of the region. Consequently, the readings of the weather stations clustered around the nation's capital (the new Federal District having been carved out of Goiás when Brasília was built three decades ago) can be taken as proxies for the situation at large.

Table 4 shows rainfall data in Goiás State. Preliminary inspection of these data shows considerable stability in data for precipitation over years, both as to their mean and distribution around the mean. The numbers for Goiás match well those of the *cerrados* in general. Furthermore, inspection indicates that the heaviest average rainfall occurred in December in the first series

Table 4
Rainfall in the Brasilia Region
Mean Precipitation, in mm
1930-74, 1975-86 and 1930-86

Month	1930-74	1975-86	1930-86
January	239.5	315.2	273.0
February	210.0	177.9	175.8
March	225.9	190.5	211.7
April	107.4	106.0	105.4
May	17.8	36.2	25.8
June	3.4	5.6	4.3
July	5.4	6.1	5.7
August	6.1	12.7	8.7
September	37.0	36.1	36.6
October	144.6	140.5	142.9
November	254.9	197.3	230.4
December	330.0	222.7	283.3
Total	1,580.2	1,446.8	1,503.6

Source: Wolf (1975) and DNAEE (Nat. Dept. for Water and Eletr. Power)

(1930-74), and in January in the second (1975-86). This difference might be due to the difference in the lengths of the series.

The 'Veranico' Dry Spells

Present knowledge suggests that the picture is reasonably stable, with respect to the onset and end of the rainy season, and variations in the volume of rainfall and in temperatures. It is less clear, however, in the case of the occurrence and duration of *veranicos*. A study of a series of 42 to 47 years of rainfall data in the Brasilia region by Wolf[10] indicates the following:

a) dry spells during the rainy season occur mainly in December and January. The 20-day period from December 27 to January 15 contains the greatest number of dry days, compared to any preceding or subsequent 20-day period;
b) in any given year, there is only an 8% chance that the longest dry spell will not exceed 8 days. In other words, in only one year in eight the rainy-season rainfall will be that well distributed;
c) there is a 50% chance that the longest dry spell will last 14 days or more;
d) there is a 15% chance that the dry spell will last longer than 3 weeks.

The findings of Wolf[11] are comparable to those of the present study. There are two explanations for the differences encountered: first, we used a shorter time period; second, we used a different definition for a dry day. Here we defined a dry day as one with no rainfall at all, whereas Wolf used 5 mm or less as the cutoff value. This explains a greater frequency for dry days in the Wolf study — 65% — as against 41% in our study, for the same period.

The calculated frequencies indicate that one can expect:

a) five *veranicos* lasting 7 days or more to occur in 3 years;
b) four lasting 8 days or more in 3 years;
c) three lasting 10 days or more in 4 years;
d) one lasting 13 days or more in 2 years;

10 Wolf, V., 1975: *Water Constraints to Corn Production in Central Brazil*. Ithaca Cornell University, (Doctoral Dissertation).
11 Ibid.

e) one lasting three weeks, in 21 years.

The comparison of data from this study with those of Wolf's suggests that rainfall in the region has been quite stable with no significant change from one period to another.

Soil-Water-Plant Relationship

In the *cerrados*, growing annual crops during the dry season requires irrigation. However, without the benefit of irrigation, most of the Goiás State crops are grown in the rainy season, typically in latosols (both reddish brown and yellowish brown) that are deep, well drained, with infiltration rates of 17-22 cm/hour, acidic (pH below 4.5), deficient in nutrients and generally containing high levels of toxic aluminum (saturation above 60%). Only plants well adapted to these conditions can prosper in such soils and withstand dry spells as well, which means a deep root system occupying a large volume of soil. Some crops can withstand dry spells of up to 21 days without a loss in yields, provided the soil conditions are improved with respect to toxicity, acidity and lack of nutrients. Thus, soil management can be a major factor in minimizing the effects of dry spells on crop yields.

Effects of Veranico on Upland Rice and Corn

Upland rice is one of the region's foremost crops and is highly susceptible to the effects of drought, especially in the swelling and flowering states (when drought also promotes attacks on plants by *elasmopalpus lignoselus* caterpillars). Corn, an economically important crop, functions as an ideal indicator of stress in the plants' hydrodynamic system and in the nutritional deficiencies associated therewith.

Two approaches were used to assess the impact of *veranicos* during the rainy season on Goiás State's corn and rice crops. First, we analyzed experimental data from the research institutes of EMBRAPA (Brazilian Agricultural Research Agency) and/or reported in the literature. Second, we applied statistical methods of analysis to aggregate crop data for the State of Goiás.

Evaluation of Experimental Data

Wolf (1975) estimated a response function based on experimental data and on the prediction that corn production is nil after 22 successive rainless days. Combining this response function with the statistical probabilities of *n* successive rainless days during the rainy season, one could conclude that, in terms of long-term averages, yields will only reach 54% of what would have been obtained had irrigation been used during the rainy season. In other words, with irrigation, long-term average yields would practically double.

Espinoza et al.[12] report on a study conducted by CPAC/EMBRAPA, during the 1975-76 and 1977-78 seasons with corn grown in LVE (Reddish-Brown Latosol) soil, designed to evaluate the effects of supplementary irrigation and planting density on the water deficit caused by artificially induced *veranico* dry spells. Again, the results indicated that supplementary irrigation would double corn yields.

In the case of rice, Stone et al.[13] showed a highly significant negative correlation between grain production and the duration of *veranico*. Thus, a 4-day dry spell reduced production by about 60%, while at 8 days the loss was close to 87%. The rainless periods were artificially produced in greenhouses and were equivalent to longer periods under field conditions.

Evaluation Based on Secondary Data

The purpose of the analysis below is to establish a relationship between the actual yields of corn and upland rice crops obtained during the 1963-86 period in the State of Goiás, and the occurrence of veranico dry spells during the annual rainy seasons.

The model considered yields (of rice and corn, in kg/ha) as a function of the volume and timing of rainfall and the number and

12 Espinosa, W., Azevedo, J., Batista, L. A. R., n.d.: *Efeito da Densidade de Plantio e da Irrigação Suplementar Sobre a Resposta de Três Variedades de Milho* (Zea mays L.) *ao Deficit Hídrico na Região dos Cerrados*. Planaltina, EMBRAPA-CPAC, mimeo.

13 Stone, L. F., Steinmetz, S., Santos, A. B. dos, 1984: "Manejo do Solo e da Cultura para Minimizar o Efeito da Deficiência Hídrica na Produtividade do Arroz de Sequeiro". Informação Agropecuária, Belo Horizonte, 10(114), 33-8.

duration of dry spells. It also allowed for trend, included in order to ascertain the effect of relevant variables, particularly changes in technology during the 1963-86 period. The inclusion of the number and duration of dry spells as variables was intended to test the hypothesis that it is not necessarily the volume of rainfall, but rather its distribution at critical periods, that affects the yields of crops.

The results of the calculations show that the volume of rainfall variable has no significant effect in any of the periods studied, except, in the case of rice, for November through January and January plus February; in the case of corn, no significance was found for this variable in any of the periods. Even in the significant cases, levels of probability were very low (although at least the sign of the coefficient was positive), as expected.

As far as the occurrence and duration of dry spells were concerned, the findings showed that spells lasting 7 days or longer were much more harmful in January and February than over the entire November-through-March period.

Other results of the model made it possible to evaluate the elasticity of the yields with respect to variations in the number of dry spells lasting 7 or more days. On the average, that elasticity was -0.0757 for rice and -0.0547 for corn. This is equivalent to saying that a 10% increase in the number of 7-day dry spells in January and February would lower rice yield by 0.7% and corn yield by 0.5%, thus suggesting that rice is more sensitive to this factor.

The model estimated veranico losses computed for rice and corn, defined as the difference between the yield estimated on the assumption that no veranicos had occurred, on the one hand, and either the actual yield or the yield estimated with the inclusion of the veranico effect (whichever is greater) on the other.

Although the elasticities were found to be low, the losses themselves were not necessarily low. When calculated on a year-by-year basis (as opposed to an average basis), losses amount to significant quantities. Thus, while in the case of corn the average annual loss in the State of Goiás over the 1963-86 period was 39,600 tons (3.4% of average annual production), the actual loss reached 150,000 tons in 1971 and 140,000 tons in 1977.

It should be noted that the predictive power of the model was greater in the case of corn than for rice: of the 13 years that featured veranicos lasting 7 days or more, the computations indicated corn crop losses in 11 years. In the case of rice, that number drops to 9. Perhaps the dry spells occurred more frequently during less critical periods in the case of rice, or else the farmers adopted mitigative strategies.

The findings allow the inference that growing corn or rice in the State of Goiás, without the benefit of irrigation, is a risky endeavor, unless defensive measures are taken. While individual losses may not be high, they are significant in the aggregate. In fact, they are not great because farmers probably do adopt defensive strategies.

The volume and value of the losses provide a measure of what society should be willing to pay in order to help farmers find appropriate ways of preventing or minimizing veranico damage. As far as individual farmers are concerned, it behooves them not only to do the same, but do so through strategies that will raise yields in the process.

Until recently, it was common practice in Goiás to use the so-called rice-and-pasture cropping system, which consisted of growing rice for 2-3 years as a self-liquidating nurse crop for pasture, if no *veranico* dry spells occurred.

Now, the government's decision to develop the *cerrados* should be based on scientifically sound practices that should ensure a fair return for investment. The region enjoys the benefit of a competent agricultural research system that in less than 10 years developed all the basic data needed to utilize the *cerrados* region with these as well as other more effective cropping systems.

Concluding Comments

The main conclusions drawn from the findings of this study are the following:

- unless counteracted with precautionary measures, veranicos can cause large crop losses;
- the model used, although extremely simple, managed to capture the relationship between rainfall (volume and timing) and the crop yields of *rice* and *corn* in Goiás during the 1963-86 period; specifically, (1) there is a significant positive relationship between rainfall in the January-

February period and the yield of rice; (2) there is a significant negative relationship between the number of 7-day+ dry spells in the January-February period and the yields of either rice or corn; and (3) how long the rainy-season dry spells (*veranicos*) last and how often they occur are more important factors in explaining the drop in yields than the total number of rainless days — be that during the entire rainy season or during the January-February period.

Chapter 9

DROUGHT, POWER SUPPLY AND POWER RATIONING[14]

Introduction

The basin of Brazil's São Francisco River supplies by far the largest share of the electric power consumed in the Brazilian Northeast. The gradual expansion of the São Francisco Power System (CHESF in Portuguese) started with the construction of the first generating complex at Paulo Afonso and continued for 40 years, until it encompassed seven hydroelectric plants located on that river or its tributaries, totaling 29 generating units.

In 1986, the river accounted for close to 93% of the almost 22,000 GWh produced by CHESF's entire generating capacity, which additionally included the output of ten thermoelectric plants and five lesser, non-São Francisco basin hydroelectric generating stations. (The percentage would have been even higher, if in 1987 power from the newer Northern system had not come on-line to supply the Northeast).

Lake Sobradinho in the northeastern state of Bahia, one of the world's largest manmade reservoirs, plays an important part in ensuring sufficient capacity to make up for seasonal variations in the São Francisco River's streamflow. The river's flow is heavily dependent upon rains at its headwaters in the State of Minas Gerais in Brazil's southeastern region.

As a result of drought in 1986, the river's streamflow fell to 55% of its long-term average, with a consequent drop in reservoir level to 26% of its total capacity, directly impacting the power supply

14 Based on Ricardo Régis Saunders Duarte, "The Effect of Power Rationing in Ceará." In Magalhães and Bezerra Neto, op. cit.

FIGURE 5 - São Francisco River Basin

capacity of the system. In addition, energy consumption was increasing at an annual rate of 7.6%. The combined effect of the drought-induced fall in power supply and increase in energy demand required the adoption of strict measures by the federal and state governments.

These measures took the form of a rationing system imposed upon the northeast as a whole in March 1987, featuring a 15% cut in traditional usage rates (reduced six month later to a 10% cut), for both household and business users.

As a result, total consumption in 1987 showed a 5.7% drop, indicating that rationing had made a definite impact on power usage. This study evaluates this impact in greater detail, analyzing it for its separate effects on households and on industry. The purpose is to track the effect of drought-induced power rationing on consumers, by (a) estimating this effect and (b) surveying the strategies applied by users in order to cope with the problem.

Household Users

Methodological Considerations

The major uses of power by households involve *lighting* and *appliances*, with the latter divided into such categories as true household appliances (refrigerators and other kitchen equipment, hot water heaters, air conditioners, vacuum cleaners, etc.), and entertainment equipment (TV, sound systems etc.). Power consumption for these various uses, as well as ownership and use of the appliances, are unevenly distributed among the population, some being quite universal (e.g., electric lighting), while others are restricted to the upper income groups (e.g., air conditioning), and still others almost non-existent in Ceará (e.g., electric cooking ranges).

In addition, among these applications, the feasibility and ease of restricting power consumption also vary from case to case. In some cases, power usage can be reduced (e.g., lighting, air conditioning) or replaced (e.g., cooking with gas, eating in restaurants) to a considerable extent, without too much difficulty. Undoubtedly, however, there is a minimum limit below which further cuts would encounter much resistance.

The relative ease (or difficulty) of reducing power consumption for certain applications is also reflected in responses to price increases. While experience has shown power consumption by households to be relatively price inelastic, this inelasticity tends to decrease as household income goes up. (As a matter of fact, findings in this study suggest that the impact of rationing was considerably stronger than that of a hefty 34.7% price increase).

The effect of rationing on household users was analyzed by examining changes in monthly bills for electricity. Consumers were divided into three groups (by the amount of power used). In view of the above-mentioned price increase, we tried to apportion the total drop in consumption (which amounted to 12.7% of the pre-rationing level) between two factors, price increases and rationing.

We did this by adopting a model of the form

$$D = T \times C(T, R) \quad (1)$$

where D = expenditure on electricity; T = residential rate, in real terms; C = consumption of electricity; R = a variable representing rationing.

By derivation, (1) yields

$$dD/D = dT/T\,(1 + C) + E.dR/R \quad (2)$$

where C = price elasticity of consumption; E = elasticity of the rationing effect on consumption.

In (2), the second right-hand term represents the effect of rationing on total expenditures for household power. This effect can be estimated from known data on variation in expenditures (dD/D) and real variation in rates (dT/T), and estimates of the price elasticity of power consumption (C).

The rationing effect measures the reaction of consumers to the rationing campaign, a campaign which combined exhortations to save power with threats of fines and power cutoffs.

Consumers were divided into three categories by levels of quarterly power consumption (Class I = 0 - 100 kWh; Class II = 101 - 300 kWh; Class III = above 300 kWh). Quarterly data for the different variables during the period of rationing in 1987 were compared to their opposite number during the same quarter in 1986, when no rationing was in effect. (For all practical purposes, rationing lasted 9 months — the second, third and fourth quarters of 1987).

Results

For Class I (smallest users), the results for all quarters analyzed showed a significant *increase* in the number of consumers and in class expenditures. This is attributed to the fact that, during the period surveyed and because of rationing, there was a significant migration of households from a given class to the class immediately below.

Thus, the population — hence the total consumption and total expenditure — of Class I increased (in the case of population, by an average 18.2% per quarter), although the average *per household* consumption duly dropped. (Low-level consumers of electricity would have been, in fact, hard put to further restrict their power usage, a fact recognized by rationing authorities when they exempted consumers of less than 80 kWh altogether).

In Class II (medium-sized consumers), total expenditure by all households during the rationing period increased by an average of 12.9% per quarter (even though the population of that class decreased by an average of 17.7%), indicating that lower consumption (due to rationing) did not suffice to offset the 34.7% price increase. Consumption was indeed lower for the entire class (an average of 19.2% per quarter), as was *per-household* consumption (an average drop of 1.5%).

Only in the case of the top Class III did total power expenditures for that class during the rationing period drop (by a quarterly average of 15.8%), although it is probable that most of that decrease was due to the smaller numbers of consumers in that class, rather than to the effect of rationing in order to compensate for the higher rates. There were also some significant decreases in quarterly *per-household* power consumption, in that class, averaging 7.5% per quarter.

Analyzing the behavior of Class Expenditures for power, over the three classes, we find an overall increase, as was to be expected in view of the rate increase. The two lower consumption groups feature an average per-household increase in expenditures for electricity of 32%, while in the top class the average rise was only 24%.

Rio São Francisco/San Francisco River

Most important for our purpose is the fact that change in expenditures can be apportioned by cause, between two additive factors. Of these, the first is the *price effect*, the impact of higher rates on the increase in expenditures. Since a single estimate of price elasticity was used for the three classes, the calculated effects are the same, although this procedure undoubtedly produces an underestimation for the lower classes and an overestimation for the top class. The fact that the elasticity has a positive sign indicates that consumption is inelastic.

The second factor is the *effect of rationing* on the change in power expenditures. Over the three quarters, total expenditures of bottom-class consumers rose by an average 39.3%, because so many consumers had moved downward from the upper classes.

The next two classes feature average per-quarter drops in expenditures for power (due to rationing) of 8.2% and 33.2%, respectively. Here, there is substantial evidence of the effect of rationing in lowering class power expenditures.

Not surprisingly, the drop is greatest in the top consumption class, because it is where the effects of two phenomena coincide — the decrease in the population of this class (losses to lower classes) and the drop in class consumption, which averaged 37.3% over the rationing period. This is almost double the equivalent figure for the intermediate group (whose consumption dropped by 19.2%).

Finally, a word about average *per-household* consumption. Changes were small from one quarter to the next within the same Class. The two lower classes decreased their consumption by 1.5% and 1.8%, respectively, while top consumers reduced theirs by an average 7.5%.

This makes sense, since top-group consumers had a much wider margin for cutting down on power consumption than lower classes, which tended to approach an irreducible minimum.

The results show that rationing was effective; more so with its system of appeals and threats than the increase in price rates, however sharp.

Manufacturers

In general, Ceará manufacturers used one-third of the state's power in 1987, although manufacturing does represent the single largest use of electricity as well as the fastest-growing one. The annual growth rate in industrial power use has been about 9%.

As was the case with the household sector, the manufacturing sector also had a number of options for dealing with the rationing problem. Here again, a given industry could:

a) find ways of using less power for the same processes and output;

b) switch to other sources of energy;

c) pursue business-as-usual and simply reduce output.

Of these options, (a) is quite feasible, whenever the production process features a significant portion of wasted power such as poor power factors, poorly adjusted equipment, or obvious wastage (e.g., letting equipment run idle for long periods).

Option (b) involves changes in technology which might (or might not) be cost effective, particularly in emergencies, i.e., normally of short-term duration. Consequently, Option (c) will be frequently chosen, and will be reflected in drops in production and employment.

Unfortunately, available statistical data are not of a nature to permit tracing the effects of the power shortage in individual industries. The researcher, therefore, is restricted to whatever information is provided in power consumption figures supplied by industry. Even here, however, there are pitfalls: it cannot be automatically assumed that drops in production levels are the direct consequence of power shortages.

As a result, our analysis is confined to estimating the possible impact of decreases in production, as a consequence of reduced power consumption. In other words, we estimate how much the value of the manufacturing product within the state may have fallen because of power shortages, assuming that all other factors (such as technology) were kept constant, not only during the rationing period but since 1980, the date of the most recent industrial census. Once the drop in production was estimated, its impact on employment was calculated, using the input-output matrix developed by Lu[15]. This was then transformed into the employment-effect matrix.

In these calculations, it was assumed that all changes in production were caused by demand changes so as to obey

15 Lu, M., 1979: *Montagem de Matrizes de Relações Intersetoriais Nacionais, a partir de Dados Fiscais e Suas Desagregações.* FIPE, São Paulo.

equilibrium conditions in the intersectoral relations of an open Leontief input-output model. In other words, the effect on employment was calculated on the basis of changes in the final demand of each industry, compatible with the drop in production caused by power rationing.

The period analyzed coincides with the three quarters covered in the case of residential power consumption (April through December). Again, comparisons were made between consumption during rationing and consumption during the same quarter in the preceding year (1986). This also helped to eliminate seasonal factors which are significant in Ceará's industry.

Results

It was found that the use of power in the manufacturing sector dropped by 4.5% in the first rationing quarter, 8.2% in the second and 7.0% in the third. Cuts varied a great deal from one industry to another but averaged 14.3% for 1987 compared to 1986. Only four industries (paper and board, chemicals, rubber, and publishing/printing) increased their consumption of power.

Some industries showed massive cuts, e.g., mechanical construction (52.3%) and plastics (38.2%); textiles, the industry with the highest level of power consumption, showed a 21.7% drop in electric power consumption.

With respect to production and employment losses, results show that the foodstuffs industry was most affected by power cuts, bearing 35.4% of total manufacturing losses. By comparison, metallurgy took a 33.3% share of the losses, textiles 11.4% and clothing/shoes 7.3%. The losses suffered by other industries were negligible.

For purposes of comparison it should be pointed out that these losses started with the April-June quarter of 1987, coinciding with the advent of rationing. In fact, the preceding quarter, before rationing, had witnessed a significant upturn in power usage, compared to the same quarter of 1986. The latter fact provides additional support for the argument that lower production was an effect of lower power usage, not the other way around.

With respect to the nature of the specific industries most affected by the cut, these are representative of Ceará's manufacturing economy. This should not be surprising in view of the fact that the power cut was introduced across the board, without taking into account a specific industry's level of dependence upon electric power.

This raises one of the major purposes of this work, the identification of specific industries most vulnerable to power cuts. Such identification would make it possible during future rationing episodes to take these factors into account, thereby leading to a more flexible (and less arbitrary) system of rationing.

It has been calculated, for instance, that the total loss of employment amounted to 15,068 jobs, equivalent to 15.6% of the entire manufacturing laborforce in the state. Of the various industries, the food industry, as noted earlier, suffered the most (5,138 jobs lost), followed by metallurgy (3,137), clothing/shoes (1,112) and textiles (1,010).

There is, of course, a certain relationship between losses of production and of employment. Thus, the four most affected industries totaled 87.6% of the former and 84.3% of the latter. Looking at the 1980 Industrial Census, one finds that these four industries accounted for 60.6% of total industrial employment. It is unlikely that this proportion has changed significantly.

Conclusions

There is no way to get around the lack of data on Ceará's manufacturing sector. In the absence of recent figures, finding a methodology that could provide a meaningful analysis of the impact of drought on energy supply and, through rationing and price increases, on consumption, was clearly a major challenge. This, of course, underscores the crucial need for better and more up-to-date statistics.

Even the preliminary findings arrived at in this study confirm that rationing had a noticeable impact on population and industry. As a policy to cope with the short-term effects of droughts on energy supply, rationing showed itself effective. Since the possibility of another rationing spell in the future is very real, this emphasizes the need for additional research.

With respect to *industries*, our findings were predicated on the assumption that no technological changes did (or would) occur. This is not a fixed assumption and the threat of future rationing may well impel significant sectors toward adopting just such technological alternatives. In any event, the findings showed that significant losses in both the value of production and in the number of jobs concentrated in four specific industries may have occurred as a consequence of drought-induced power rationing.

In the case of *households*, findings suggested that consumers did indeed heed the call for rationing to an extent that exceeded the drop in consumption caused solely by a sharp increase in costs to consumers. This indicates that some leeway is available, especially among larger consumers, for reductions in power usage.

Finally, not only the findings on the impact of rationing, but the mere fact that rationing had to take place at all — and introduced only in the Northeast — makes it obvious that a major rethinking of power generation and supply policies is required.

Certainly, the existing dependence of the Nordeste on power generated by the São Francisco River System must be reduced. Calculations based on the last 20 years show that the Northeast's Gross Domestic Product, as a function of industrial power usage, has an elasticity of 2.36, i.e., each additional cruzeiro of manufacturing product requires more than 2 kWh in additional power. To ensure continued growth in the Brazilian Northeast, expansion of the region's power supply cannot be neglected.

Nonetheless, despite such observations, existing plans are still centered on the São Francisco river and its stations; an expansion in Itaparica, and a new plant at Xingo. It thus behooves Ceará state authorities, population and industry to face the fact that rationing is most likely to be a recurrent event.

Photo by Sommer Andrey/Abril Imagens

Agricultura – café: geadas/Agriculture – coffee: freezes (São Paulo)

Chapter **10**

THE EFFECTS OF FREEZES ON COFFEE AND CITRUS PRODUCTION[16]

Introduction

The purpose of this chapter is to analyze the effect of freezes on orange and coffee crops in Brazil, and the socioeconomic consequences thereof. This analysis covers Brazil's major producing states in the 1969-85 period.

An ulterior objective of this study is to understand in greater detail the possible implications of an important climatic event such as a freeze, on a rapidly modernizing economy. The moment is particularly propitious because we are witnessing great concern with potential global changes in climate, caused by the rising atmospheric content of trace gases such as carbon dioxide, methane, nitrous oxide and chlorofluorocarbons. Thus, although freezes have always affected crops, a set of severe freezes in Florida in the 1980s has raised the specter of a more permanent — and possibly harmful — change in climate.

This lends greater urgency to gaining a better understanding of climatic events and of policies that can deal with their consequences. Faced with the likelihood of changes, it is important that we know how society might react, based on how it has reacted in the past.

Given the twofold nature of this study and the sharp differences that distinguish the two crops (not only in how they are affected by frosts but also in the administrative and regulatory framework into which they fit), we have chosen to discuss the impacts of freezes on coffee production and on orange production separately.

16 Based on Ana Maria Castelo and José Juliano de Carvalho Filho, "Coffe and Citrus Crops in Brazil and the Socieconomic Effects of Freezes." In Magalhães and Bezerra Neto, op. cit.

Governmental Policies

Coffee has been one of Brazil's economic mainstays since the last century, when coffee exports started to represent a major source of foreign exchange. Even now in the midst of the process of industrialization (a process in which coffee has played a decisive role), coffee is still Brazil's principal export product.

Because of its important position in the country's economy, the coffee business has always been subjected to considerable government intervention, with the authorities either controlling the supply of beans, or supporting their price, or both. A special entity, the Brazilian Coffee Institute (IBC), was set up to devise and implement coffee policies.

Thus, in the late 1950s and 1960s official emphasis was on keeping a lid on supply, along with holding down the costs of the price-support policy. The result was a policy of administered prices and a program of tree eradication and crop diversification. During that period, unfavorable weather (in particular, severe frost in the late 1960s) acted to reinforce official policies, contributing to a sharp drop in Brazil's coffee production. As a result, the oversupply situation of the 1950s and 1960s was reversed, with a 46% reduction in annual volume by the 1970s.

This state of affairs prompted a reversal in the government's approach. The new policy was designed to stimulate the planting of coffee trees. Thus, in the 1970-71 crop year, an ad-hoc committee, the Executive Group for Renovating Coffee Growing (GERCA), operating as part of the IBC's Production Department, drafted a Plan for Renovating and Reinvigorating Coffee Plantations (PRRC). The PRRC, originally scheduled to operate until 1975, aimed at stimulating improved coffee growing through a program of seedling production, planting, fertilizer usage, soil management, and pest controls. The stimulus consisted mainly of subsidized low-cost loans.

In 1975, following a severe frost that hit Brazil's entire South-Central region, the PRRC program was extended to 1981 in a redrafted version that addressed the need to reclaim coffee plantations damaged by the freeze, especially in the states of Paraná and São Paulo. Since then, the Program to Finance Planting concerned itself with the location and size of planted areas, trying to shift these to relatively frostfree regions suitable for coffee growing.

In 1979, when another bad freeze adversely affected coffee production, and again after the 1981 freeze, the plan for reclaiming freeze-damaged plantations was resurrected. From then until the 1983-84 crop year, governmental incentives and recovery aid were embodied in the Operating-Expense Loan Program.

Coffee Growing and Ambient Temperatures

The coffee tree is small and shrub-like, of continuous growth that requires a narrow range of temperatures averaging 16°C to 23°C. The effect of temperatures outside these limits will depend on the degree and duration of the deviation, as well as on other factors such as soil moisture, wind, rainfall, etc.

Elevated temperatures depress plant growth and cause the premature development and ripening of the fruit, with consequent loss of quality. If a heat wave occurs while the tree flowers, there will also be a loss in yield. Under direct intense sunlight, net photosynthesis starts to drop above 24°C and reaches zero at 34°C. Furthermore, temperatures above 30°C cause tumors at the base of the stem.

Consequently, coffee plantations in equatorial regions are generally located at high altitude. However, susceptibility to high temperatures varies from species to species. Thus, Arabian coffee (*coffea arabica L.*) requires milder average temperatures (even though the species is of equatorial origin), while robusta coffee (*Coffea canephora Pierre*), originally from low-lying, hot areas, can withstand temperatures between 22°C and 26°C.

Cold weather can also reduce coffee tree growth to a significant extent: below 12°C growth is completely inhibited. Discoloring of the leaves and frost-burn of the tips is also frequently observed, particularly at higher altitudes. The greatest damage occurs below 3°C, which is the internal freezing point of the tissues. Indeed, the mere presence of frost on a coffee tree does not necessarily cause serious damage. It is the internal freezing of the tissues that must be avoided at all cost, when frost strikes plantations.

Obviously, the extent of frost damage will depend on its intensity; temperatures below 2°C close to the soil will cause stem strangling in young trees, a condition which normally leads to the death of the affected bark tissues. The consequence will show up after the tree has grown, in a strangled stem at the damaged level. This occurrence is known as *frost shin*. Temperatures below 5°C to 7°C will kill the tree outright.

Damage to the fruit, on the other hand, may occur indirectly, i.e., the temperature drop will not affect mature fruit, but will produce its effects on the next crop. If the freeze hits while the fruit is still maturing, however, and the damage is severe, it may require early harvesting of the tree, with deleterious effects on quality. Frosts, while the tree is close to flowering, will cause "abortions" with obvious impairment during the fructification stage.

In Brazil, coffee trees generally flower in the spring; fructification occurs in the summer, followed by ripening in the fall and harvesting in the winter. For the most part, frosts occur around harvest time.

Impacts of Freezes in 1969-85

In recent years, coffee growers have expanded geographically beyond the area traditionally occupied in the country's South-Central region, although the main producers continue to be the states of Paraná, São Paulo and Minas Gerais. There has been a switch in precedence, however, with Minas Gerais becoming the largest producer in the early 1980s, a position held for many years by the state of Paraná.

The period under study witnessed a succession of frosts of varying intensities: the 1969 freeze hit the state of Paraná and coincided with São Paulo's drought; in 1972 there was a moderate frost; the 1975 freeze was a disaster, causing losses not seen since 1918; 1978 and 1979 witnessed milder frosts, causing, however, disproportionate damage because the trees were still recovering from the prior freeze; in 1981 yet another severe frost occurred.

Table 5 shows the effects of freezes on the production of the affected states and of Brazil as a whole. Since the fruit has generally matured by the time a freeze occurs, the latter's effects show up in the following year. Thus, in the specific case of the bad 1969 freeze in Paraná, the damage became visible during the following harvest year, with an 87% crop loss there. In the state of São Paulo, 28% of the coffee crop was lost. In Minas Gerais the crop turned out to be significantly greater than the year before, although for Brazil as a whole the drop in coffee production amounted to 46%.

The following years witnessed a gradual recovery of production levels lasting until the 1973-74 crop year, when the effects of the 1972 freeze became apparent. Losses were 58% in Paraná, 25% in São Paulo, 46% in Minas Gerais and 42% for Brazil.

Once again, production slowly climbed back to the level of the 1960s only to be hit by the 1975 catastrophe. That event wiped out production in Paraná, reduced São Paulo's production by 73%, but once again left Minas Gerais unscathed. By comparison, the 1978 frost was moderate, particularly since it was confined to the state of

Table 5
Coffee Production, by State
(in 000,000,000 sacks of 60 kg)

Year	Paraná	São Paulo	Minas Gerais	Epírito Santo	Brazil
*1969	12.3	6.1	1.3	0.5	20.6
1970	1.6	4.4	3.0	1.6	11.0
1971	12.8	9.8	1.3	0.4	24.6
*1972	9.7	9.4	3.7	1.2	24.5
1973	4.1	7.0	2.0	0.8	14.3
1974	11.5	9.8	4.9	1.4	28.1
*1975	11.7	7.0	2.0	1.0	22.2
1976	—	1.9	2.3	1.5	6.0
1977	1.8	7.6	4.9	1.2	16.1
*1978	4.6	8.3	4.4	2.3	20.0
*1979	2.0	8.4	7.9	2.7	21.6
1980	3.0	6.0	3.4	3.1	16.4
*1981	8.3	11.6	11.6	3.3	35.4
1982	1.5	5.5	4.0	3.4	16.2
1983	5.9	7.4	9.6	5.1	30.4
1984	4.0	6.4	5.5	4.0	21.8
1985	5.4	8.9	10.7	5.1	32.6

Source: IBC - Statistical Coffee Yearbook / São Paulo Secr. of Agriculture
* Frost Years

Paraná. Thus, overall production in Brazil was barely affected (particularly since Paraná's potential contribution had been badly diminished by the previous disaster, and production in Minas Gerais once again continued unabated).

There was a switch in 1979, when the freeze adversely affected production in São Paulo and to an even greater degree in Minas Gerais, which lost 57% of its crop. For Brazil as a whole, the drop was 24%.

The last frost of the period occurred in 1981. It was very severe and affected all three producing states: Paraná, São Paulo and Minas Gerais. The total loss for Brazil was 54%.

The freezes have had a lesser impact on tree population and planted areas than in production. Thus, for instance, while Paraná's production had become negligible by 1976, the tree population was reduced by 24% and the area planted by 28%. As another example, coffee production in Minas Gerais was badly hurt by the 1981 freeze, yet the tree population there even grew a little, while the planted area fell by only 1%. The conclusion is that freezes weakened the trees, but did not kill them. Findings on yields substantiate this assertion. In 1975, yields were already falling and the freeze only reinforced that trend.

As far as prices are concerned, undoubtedly there were reflections of crop losses, both in domestic and foreign markets. However, any analysis is complicated by the high degree of government intervention in the coffee-growing business, counteracting oscillations by selling off some of its stocks or establishing price floors though guaranteed purchases. As a result, it is difficult to trace any relationship between crop losses and prices, although some of the market prices do suggest some link.

This is also true of export prices. Even though Brazilian coffee is a major factor in world markets, there are many variables that affect quantities and prices of Brazilian exports. If there is no evident relationship between freezes and quantities exported, this undoubtedly must be because sales from government stocks affected the outcome. As previously mentioned, it is highly improbable that the more severe frosts did not have some effect in raising prices. Indeed, in the years following the bad freezes of 1975 and 1981 prices rose abruptly.

Some of more intriguing questions raised by these statistics concern whether, and to what extent the freezes have caused the following:

- a replacement of coffee by other crops that are less sensitive to abrupt temperature drops;
- a shift of coffee-growing areas to others, less prone to such drops;
- a replacement of Arabian coffee by *robusta*.

In Paraná, during the period under analysis, there was a 63% reduction in area planted to coffee, offset by increases of 119% in Minas Gerais and 90% in Espírito Santo. In São Paulo there was first a rise, followed in the early 1980s by a drop that produced a net 28% decrease by the end of the period.

Thus, it seems clear that in the state of Paraná coffee growers switched to other crops, so that production recorded substantial increases of acreage in soybeans and wheat. Since the latter crops are less labor-intensive and are primarily grown on medium-size and large farms, this provides an explanation for the pronounced out-migration of farmworkers at that time.

Of course all this may not be attributed to the effect of freezes, however severe; the high profits yielded at that time by soybeans and wheat were undoubtedly the primary reason for the switch away from coffee. Just as surely, however, frosts must have helped to discourage potential coffee growers.

In São Paulo, reductions in coffee acreage were much less pronounced and only started in the 1980s. There are indications that coffee was replaced primarily by sugar cane and citrus, due to profit considerations as well as to plant diseases that were afflicting coffee.

According to one author Bacha[17], the smaller plantings in Paraná and São Paulo caused coffee prices to rise, which in turn stimulated larger crops in Minas Gerais. In other words, part of the sharp increase in the latter state could be attributed to reduced plantings in Paraná. In addition, not only is the state of Minas Gerais generally less frost-prone, but its coffee plantations are located

17 Bacha, J. C., 1988: "Evolução Recente da Cafeicultura Mineira: Determinantes e Impactos." São Paulo, Master's Thesis, University of São Paulo.

mainly in frost-free areas. Last but not least, Minas belongs to that relatively limited area that is suitable for growing Arabian coffee.

In other parts of Brazil, more freeze-resistant species such as *robusta* have been grown. The state of Espírito Santo is the largest producer of *robusta*, production having increased considerably in recent years. The fact that robusta is also more resistant to disease, pests, and drought undoubtedly was a factor in that development.

Review

We have seen that the coffee-growing business has been affected by freezes in the 1969-85 period. The growers' net losses depended on the severity of the frost as well as on the extent of government aid.

In the case of the severe 1975 freeze, government assistance was not sufficient to prevent major changes in the makeup of the industry, particularly in Paraná, where the problems of coffee and the lure of greater profits in soybeans and wheat resulted in sharp reductions in acreage devoted to coffee production.

However, regardless of the fact that growers' losses were in effect "nationalized" by the government, coffee plantations continue to be damaged by their vulnerability to freezes, particularly the Arabian variety.

Citrus Production

Unlike the coffee growing business, there is very little government intervention in the case of citrus. Whatever regulations exist are those affecting all businesses in Brazil, in particular those that export a significant part of their product.

Citrus and Ambient Temperatures

Citrus plants are of subtropical origin and are sensitive to extremes at either end of the temperature spectrum. Such extremes impair the rate of vegetative growth of the plant as well as the development of the fruit.

Some authors place the optimum temperature range between 22°C and 33°C. As with coffee production, 12°C is the temperature limit below which the plant enters a 'zero vegetative' stage. Conversely, above 36°C that activity starts to slow, dropping to a minimum above 42°C.

Generally, high temperatures cause burns on leaves and fruit. The former effect is caused by the destruction of chlorophyll, impairing photosynthesis, and hence, plant metabolism and nutrition. An effect seen in equatorial regions is the discoloration of the fruit's outer skin. Since there is no cold season, the fruit maintains its green skin color even after ripening, a fact that causes problems in the marketing of the whole fruit.

In the case of citrus intended for concentrated-juice production, high temperatures manifest themselves primarily in sugar formation and the sugar-acid ratio. In the absence of a winter season, ripening occurs at high temperatures which favor sugar formation to the detriment of acidity, thus lowering the processing qualities of the product. It should be noted, however, that with irrigation citrus can be grown in arid or even desert regions.

Low temperatures also damage citrus-tree leaves, branches and fruit. The extent of such damage will depend not only on the intensity of the cold but also its duration. Below 4°C, leaves and branches start to suffer; a frost of 2°C for two days can cause serious damage. Between 0.8°C and 2.8°C the fruit starts to evidence signs of damage. Low temperatures dehydrate the cells because water fills the intercellular spaces, where it freezes. Freezing causes the coagulation and impermeability of cell walls, followed by the death of the cell.

If fructification has not started, frosts will prevent or delay the germination of the pollen grains, or even inhibit the growth of the pollen tube. Either way, pollination is impaired. In other cases, low temperatures may primarily damage branches and tree bark, without killing the plant. The affected areas may recover and the plant may survive, albeit with lower yields.

Citrus reactions to frosts vary between varieties: oranges and tangerines are the most resistant while limes are most vulnerable. Other factors that influence frost resistance are states of dormancy, plant health, nutritional status and pest attacks which weaken the plant.

Impacts of Freezes on Citrus-Growing in São Paulo

The expansion of citrus production in the state of São Paulo can be viewed as a mirror image of what happened in the case of coffee. In fact, its very beginning coincides with the decline of coffee planting; furthermore, citrus utilized to good advantage the basic operating and financing infrastructure originally set up for the benefit of coffee growers.

Thus, starting in the 1930s, citrus production expanded rapidly in the state of São Paulo where conditions were most favorable. However, it was only after the fact that the advent of citrus processing had created a new market for oranges that this sector consolidated. Such processing started in the mid-1960s and by the 1970s had developed into an interconnected agro-industrial complex. Because all this took place in São Paulo, that state soon took the lead in orange production.

Another fundamental characteristic of the situation is the fact that the entire process is export-oriented. Most processed juice concentrate is sold to foreign buyers.

All these details explain how and why citrus growers react to freezes the way they do. Although citrus plantations are sensitive to freezes, economic indicators do not show the slightest sign of any consequences thereof. Thus, both production volume and planted area evidence continuous growth. Even in 1975, when frost destroyed new buds, there is no statistical indication of adverse results.

As shown in Table 6, in some years yields are lower than in others, interrupting the general upward trend, but there seems to be no correlation with frosts, particularly because orange trees are prone to a variety of diseases that affect productivity. Furthermore, other climatic factors such as droughts may be operating.

Yet, a study carried out at the Institute of Farm Economics (Silva et al.[18],) developed forecasts of yields for a number or crops

18 Silva, G. L. S. P., Caser, D. V., Vicente, J. R., 1986 (1985): *Variações do Tempo e Produtividade Agrícola: Um Subsídio à Previsão de Safras no Estado de São Paulo.* Campinas, Fundação Cargil.

Table 6
State of São Paulo
Orange Production, Yields and Prices
1969 - 1984

Year	Production (000,000 t)	Yield (t/ha)	Producer Prices (000 Cr$/t) (1983 cruzeiros)
1969	1.39	8.9	29.32
1970	1.77	9.4	29.28
1971	1.84	8.6	34.05
1972	2.43	9.7	29.00
1973	2.84	9.3	35.82
1974	3.56	9.4	20.26
1975	3.49	9.1	19.25
1976	3.98	9.7	20.79
1977	4.06	10.2	36.65
*1978	4.86	14.1	30.80
1979	6.18	15.2	17.23
1980	6.80	15.9	23.95
1981	7.16	16.9	27.94
1982	7.52	17.1	26.85
1983	7.70	16.3	20.83
1984	8.37	16.7	53.24

Source: Institute for Farm Economics, 1987
*Starting in 1978, yields were computed per unit of harvested (as opposed to planted) area.

(including oranges), using a model that linked yields to a variety of weather factors. According to that study, frosts significantly affect the yield of orange trees. Perhaps the conclusion to be drawn is that only the 1975 freeze — by far the worst in the last few decades — had any real impact.

In the case of prices, a number of other considerations prevail, starting with the fact that, in view of its intimate links with agro-industry, orange growing cannot be studied in isolation. This is particularly true when it comes to prices. Any substantial change in price will directly impact the cost structure of the processors. In addition, unlike coffee, oranges do not have the benefit either of government purchases and stocks or of minimum price support. Consequently, prices are established by direct negotiation between growers and processors; however, growers are numerous and unorganized, while processors are few and powerful.

Since most of the concentrated juice is exported, world market prices are another important determinant. It is difficult to pinpoint the effect of freezes, but whenever they cause significant reductions in supply they undoubtedly act to raise prices. So far, there have been no instances involving freezes in Brazil, but the effect certainly has operated in the case of freezes in the United States (e.g., Miller and Glantz[19],).

In the 1970s and 1980s, a set of hard freezes plagued orange groves in the United States, causing heavy losses and sharp drops in the volume of production. However, one nation's loss was another's gain; U.S. imports of orange juice concentrate from Brazil took an upward jump.

In fact, there are those who argue that there is a definite connection between freeze-induced drops in U.S. production and the subsequent expansion of the citrus industry in São Paulo (cf.*A Rural*[20],). They claim the expansion had its start as a consequence of the Florida hard freeze in 1962, and was further fueled by the frosts of 1971, 1977, 1981, 1984 and 1985, leading to the definite consolidation of orange growing and processing in São Paulo.

It is undoubtedly true that crop shortfalls and consequent price increases on the world market worked to the advantage of Brazil's citrus growers and processing industry. On the other hand, that period coincided with Brazil's rapid industrialization and economic advance, hence the expansion of internal market.

Citrus juice processing in Brazil provided a new market for growers. The quality of the product made the processed juice a success in foreign markets. Stimulated by technical advances in the processing sector, growers themselves adopted modern techniques, switching to a greater use of mechanical equipment and a salaried laborforce.

Freezes in the U.S. continue to trigger booms in the Brazilian citrus industry. In 1971, the rise in Brazilian citrus exports was 131%; in 1981, 5.9%; in 1984, 64%. However, average export prices show an opposite reaction, rising more in 1984 (46%) than in 1971. Indeed,

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19 Miller, K. A., and Glantz, M. H., 1988: "Climate and Economic Competitiveness: Florida Freezes and the Global Citrus Processing Industry." *Climate Change,* 12, 135-164.

20 Revista *A Rural* (1980). "Novas Fronteiras da Cafeicultura se Consolidam com Boas Surpresas." 59(563):7-10 February.

exports from Brazil today curtail freeze-related price increases in the U.S., thereby protecting the U.S. consumers.

The 1981 Florida freeze was a boon to the Brazilian industry. Because of a huge crop, the market had been swamped with an extra 150,000 tons of orange juice for which there were no buyers. The Florida freeze was a "savior" that year for Brazilian orange exporters. In addition, the Brazilian policy of modernizing the citrus production and processing sector, together with excellent quality and low prices, made it possible for São Paulo to take advantage of Florida's weather-related misfortunes.

Conclusions

In tracing the impact of frosts on citrus and coffee growers in Brazil, this study established the overall thrust of these impacts on production, processing, planted areas and operating policies, while at the same time making it clear that a variety of other factors influence such variables. One of the more important of these factors has been the formation of integrated agro-industrial operations.

A succession of frosts may lead producers to seek other investment options, provided the profitability of the alternative is attractive. On the other hand, the operation of special government subsidies that 'nationalize' freeze losses may prompt growers to take their chances and stay put. In any event, the fact that other options are available to growers further acts to attenuate any dramatic consequences, even of catastrophic frosts.

Chapter **11**

THE EFFECTS OF CLIMATE ON AGRICULTURE IN SÃO PAULO STATE[21]

Introduction

Weather affects crops at each of the several stages of their biological cycle and is a factor throughout the entire production process. For their part, weather-related fluctuations in the supply of farm products will trigger fluctuations in crop prices, hence in farm income, with further effects on domestic and export availabilities and on the crops' overall price level. In the case of extreme meteorological events (e.g., droughts, floods, severe freezes), supply upheavals may occur that are capable of affecting the economy as a whole. Consequently, private and public decisions that can affect farming activities must be seen as sources of uncertainty.

Official responses to these problems have generally been confined to building up reserve stocks, regulating foreign trade, regulating prices, and setting up special farm-loan programs designed to help the stricken sectors. Nevertheless, successful policies require precise information on how weather affects harvests.

Consequently, much effort has been expended on obtaining reliable early forecasts and final estimates of farm production volumes. In the state of São Paulo the Secretariat of Agriculture has been systematically collecting, processing and publishing crop forecasts since the 1940s. The data are used as inputs in drafting public policies, helping farmers and others plan their activities, and in support of scientific research. Efforts have also been made to design predictive models for planted areas, yields and crop

21 Based on José Roberto Vicente, Denise Viani Caser and Gabriele Luiz Seraphico Peixoto da Silva, "Adverse Climatic Events: Estimated Crop Losses and Government Responses in the State of São Paulo." In Magalhães and Bezerra Neto, op. cit.

production estimates. Silva et al.[22] proposed models linking the yields of major São Paulo crops with variations in weather.

More recently, awareness and concern have been spreading among farmers, agronomists, climatologists and social scientists about the possible regional effects of climate variability and change on agriculture. This concern may have been due to speculation: first, under certain circumstances modern farm practices have made crops more vulnerable to climate; second, there have been signs of certain man-made changes in regional climate patterns.

This study aims to (a) obtain estimates of losses caused by unfavorable climatic conditions of cotton, rice, coffee, sugar cane, oranges, corn, and soybeans in the state of São Paulo; (b) investigate if such losses could be explained by changes in the patterns of adverse climate events, and by possible increases in the crops' water requirements as the result of higher yields; and (c) study official responses to such adversities, as exemplified by the severe freeze of 1975 and by the extended drought of 1985, both of which affected the state of São Paulo and the entire South-Central region of Brazil.

The models that generated the findings analyzed in this study follow the general form

$$R = f(M, T),$$

where R is crop yield, M are variables representing weather conditions, and T are trend variables for long-term changes in technology, in the proportion of production factors, in soil loss and fertility, or in crop location.

In all cases, month-to-month water deficits were used, as were binary variables representing the occurrence of sharp or moderate freezes (for cotton, rainfall at harvest time was also included). Generally, a single trend variable was used. In the case of rice and coffee, however, two such variables were required.

Results and Discussion

The results of this exercise showed that, in the case of the 7 crops considered in the study, climate variability is a very important

22 G. L. Peixoto da Silva, J. R. Vicente, and D. V. Caser, 1986: *Variações do Tempo e Produtividade Agrícola: Um Subsídio à Previsão de Safras no Estado de São Paulo.* Campinas, Fundação Cargil.

variable influencing both productivity and production outcomes. In some cases, like coffee production (also considered in other studies in this volume), the impact of extreme meteorological events can seriously affect the agricultural activity itself and can lead to the substitution of other more resistant crops.

The following table shows the estimated loss in productivity that resulted from any kind of climatic abnormalities during the 1958-87 period. In many cases, such losses in productivity were represented by very high losses in production. For instance, losses in rice crops because of water deficiencies have been as high as 51% in some years within the research period.

It must be emphasized that, for most crops, there has been a substantial increase in productivity in the period, due to incorporation of capital and modern inputs. This implied, on the other hand, greater water requirements of plants, thereby explaining the increasing productivity losses. Such was the case for cotton, rice, sugar cane, corn, and soybeans (and also oranges), in the 1978-87 period, as compared to 1968-77 (Table 7).

Table 7
Change in Productivity Due to Adverse Climate Impacts on Agriculture in São Paulo

Crop	1958-67	1968-77	1978-87
Cotton (kg/ha)	67.00	101.00	117.00
Rice (kg/ha)	131.00	242.00	346.00
Coffee (60 kg sacks/1000 trees)	3.10	3.80	2.80
Sugar cane (tons/ha)	2.60	3.09	3.21
Oranges (90-lb boxes per tree)	0.14	0.08	0.12
Corn (kg/ha)	58.00	122.00	160.00
Soybeans (kg/ha)	28.00	80.00	77.00

Government Responses

With the exception of coffee production, for which a strong government presence was greatly reduced in 1990 when the Brazilian Institute for Coffee was abolished, government policy has been limited to providing credit to farmers and to intervening in the pricing and commercialization system. In the last few years, this role of the government has been hampered by the shortage of official funds.

In some years during the 1958-87 period, however, the federal government has been able to finance substantially the agricultural sector in the state, helping farmers during major drops in production. This has been a cause for the overestimation of predicted crop losses. For instance, the extended drought of 1985 prompted predictions of catastrophic losses in farm production. In the state of São Paulo, estimated losses ranged from 33% for soybeans, up to 34% for corn, 37% for rice and 55% for cotton. After the drought event, final figures came to a 7% loss for cotton, 5% for soybeans, 4% for corn and 0.6% for rice. Among annual crops, only summer beans and summer peanuts suffered heavy losses (53% and 37%, respectively). In the case of beans, this drop was attenuated by the almost-normal performance of the upland- and winter-bean harvests, which was -6% and -4%, respectively. Thus, the total shortfall of the bean harvest was about 24%.

Meanwhile, the government spent a lot of money on food purchases in foreign markets. Although planting had been delayed, the weather was favorable and the feared drastic drop in production did not materialize. Compared to 1985, food imports in 1986 increased by 380% for rice, 520% for beans, and 232% for corn. Imports turned out to be excessive, provoking storage difficulties in connection with the new crop harvest, further complicating Brazil's already deteriorating balance of payments situation.

Conclusions

These findings suggest that water deficiencies, freezes and harvest-time rainfall caused considerable losses to all major crops in the state of São Paulo. This may also be valid for most other Brazilian states.

The data indicate that, generally, these losses have increased in recent years, in keeping with the trend towards greater yields and, hence, greater water requirements. This observation suggests the development of an enhanced sensitivity of modern (yet non-irrigated) farming to climatic variability.

It is also true that recent years have witnessed more frequent occurrences of adverse weather conditions, particularly those resulting in water deficiencies. Consequently, the findings regarding higher losses in recent years compared to the initial 10-year period of the survey (1958-67) may have been the result of both of these factors. Government responses to these climatic adversities consisted mainly of protective measures for coffee growers in the year following the freeze, and of food imports in the drought year.

Additional research is needed on (1) the effect of crop losses on prices, farm incomes, employment and wages of farm workers, and consumer expenditures; (2) the effectiveness of public monies expended on mitigating the economic impacts of adverse climatic conditions; and (3) the implications with respect to macroeconomic policy of increasing fluctuations in the supply of farm products.

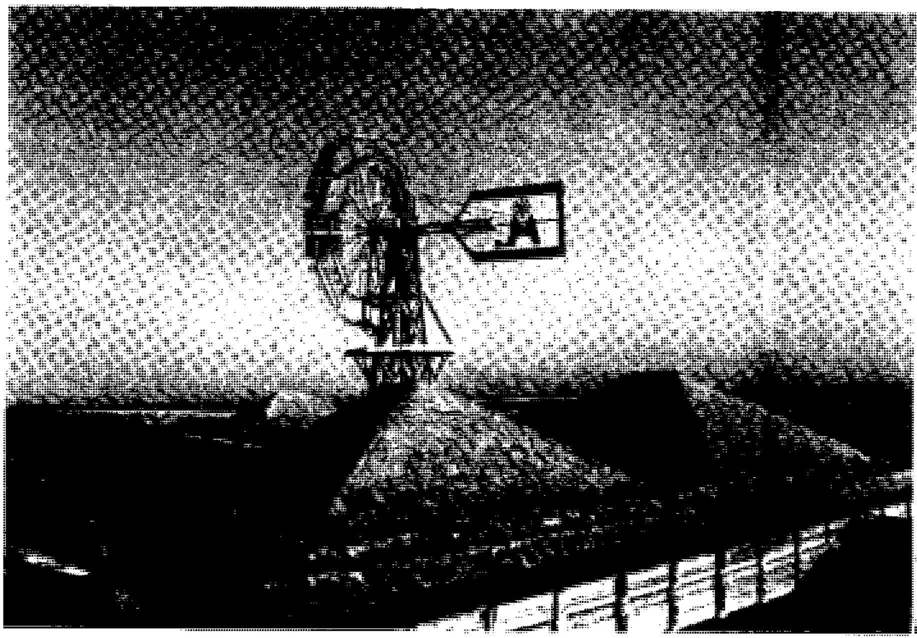


Photo by Sérgio Dutra/Abril Imagens

Salina/Saline – (Rio Grande do Norte)

Chapter 12

THE EFFECTS OF FLOODS AND DROUGHTS ON THE SALT INDUSTRY[23]

Introduction

Solar salt is obtained from sea water that evaporates naturally in large shallow ponds that have been constructed either from man-made materials or by utilizing the naturally available substrates such as clay soils. Salt ponds (*salinas*) are generally set up close to, but not on, the sea shore, as well as close to river deltas.

Northeast Brazil provides an ideal location for *salinas*, because of its long coastline, many hours of sunshine per year, rains restricted to a well-defined rainy season, quiet shore, inexpensive land, and constantly blowing trade winds. The Northeast is Brazil's main solar-salt supplier region, seconded only by the State of Rio de Janeiro in the Southeast region.

Climatic factors play an important role in the operation of solar-salt ponds, which is why the subject was included in this study. By their nature, salt ponds thrive on droughts, thus providing a counter-cyclical opportunity for unskilled farmworkers: during the rainless "summer" — or even drought-stricken "winters" in which the rainy season fails to materialize — farmworkers could find gainful employment at the *salinas*, were it not for the limited capacity of the salt industry to generate many job opportunities.

This study represents an effort to investigate the solar-salt industry in Ceará, trace the effect of various climatic factors on the industry, and identify the causes of the differences in the activity between two states — one, Rio Grande do Norte, a success story; the

23 Based on Francisco de Assis Soares and Sandra Maria Santos Cartaxo, "The Effect of Climate on Ceará Salt Industry." In Magalhães and Bezerra Neto, op. cit.

other, Ceará, a story of difficulties and failure. The main producer in Brazil is the state of Rio Grande do Norte. Although the state of Ceará has the same benign climate as Rio Grande do Norte, its salt industry has been languishing, notwithstanding the fact that both are subject to the same climatic variabilities and have similar conditions with respect to natural resources availability, levels of economic development, tradition in the salt industry and manpower capability.

Solar Salt in the Northeast

The Northeast region is responsible for 80% of the solar salt produced in Brazil. Beginning in 1960, Brazil produced 922,900 tons of solar salt, of which 63% came from Rio Grande do Norte and 16% from Ceará. The rest came mainly from Rio de Janeiro. In 1985, total production reached 1,743,900 tons and Rio Grande do Norte increased its share to 77%, while Ceará decreased its share to 2%. In between, there has been a lot of variation. In some years, like 1984, Rio Grande do Norte alone produced 87% of Brazil's total solar-salt production (see Table 8).

Rio Grande do Norte has excellent meteorological and topographical conditions for solar-salt production. The coastal plains are cut by sea branches and natural canals, vegetation is sparse, and there are permanent winds blowing from the sea. Precipitation is low and concentrated in three to four months of the year. Evaporation is very high, a condition that is essential for salt production. Soil is composed of a superficial impermeable clay at the land's surface. All these make excellent conditions for salt production.

In the neighboring state of Ceará, similar conditions are encountered. There are plains where the sea-water intrusion can be incorporated into solar-salt ponds. There are soil conditions similar to those in Rio Grande do Norte. There are permanent sea winds that, together with high temperature and low precipitation, provide high evaporation rates. Notwithstanding the fact that Ceará possesses favorable natural conditions, its salt industry has not fared well. In 1960, Ceará produced 149 thousand tons of solar salt. In 1986 it produced only 35 thousand tons, a mere 2% of the national production.

There are several hypotheses about the causes for the different performances of the two states:

a) differing sensitivities to climate variability;
b) differing nature of government intervention;
c) differing endowment of entrepreneurship; and
d) differing endowment of technology and capital.

The Effects of Climate Variability

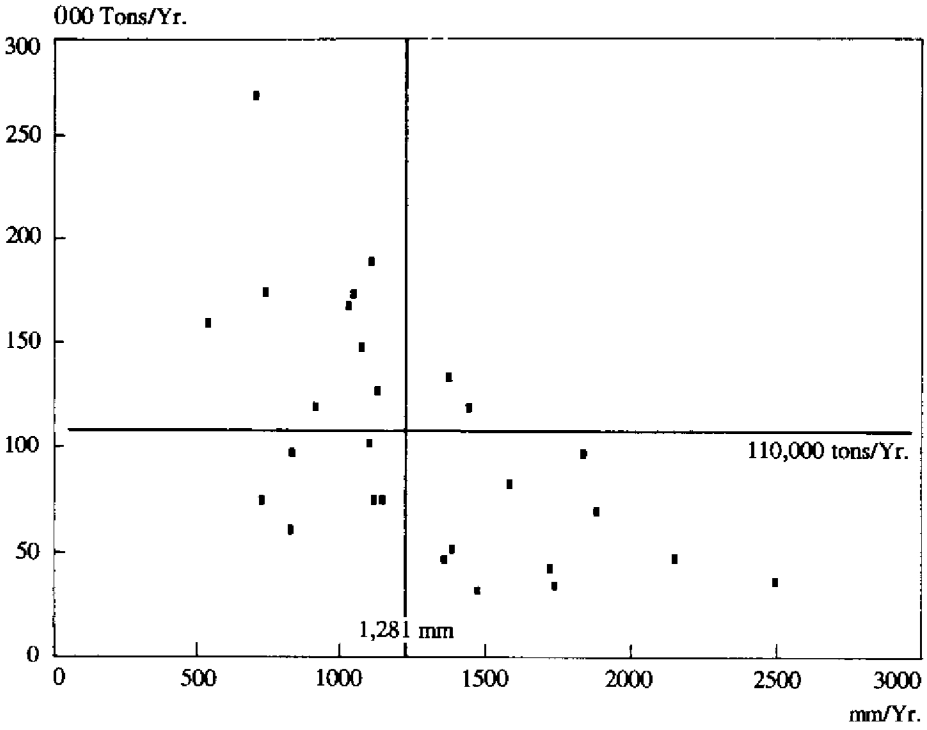
The solar-salt industry is highly sensitive to the vagaries of climate, although the degree of sensitivity is greater in the low

Table 8
Salt Production and Climate Variability
States of Ceará and Rio Grande do Norte
(1970 - 1986)

Year	Drought (d) Non-drought (nd)	Solar-Salt Production (000 tons)	
		Ceará	Rio Grande do Norte
1969	nd	169.4	1,117.9
1970	d	270.5	1,095.3
1971	nd	84.5	916.6
1972	d	191.0	1,551.1
1973	nd	43.6	1,328.5
1974	nd	48.8	971.3
1975	nd	32.4	1,631.3
1976	d	76.1	1,880.7
1977	nd	53.8	1,864.6
1978	nd	75.7	2,113.0
1979	d	75.4	2,266.6
1980	d	97.6	2,547.0
1981	d	61.6	2,348.2
1982	d	120.2	2,337.2
1983	d	159.7	2,651.6
1984	nd	48.0	3,126.5
1985	nd	38.3	1,339.9
1986	nd	35.3	1,545.1

Source: Federal Executive Commission of the Salt Industry, quoted by Soares and Cartaxo, op. cit.

FIGURE 6 – Scatter Diagram of Solar Salt Production – State of Ceará



Note: Scatter diagram showing 1960-86 solar-salt production (in 000 tons/year) of Ceará's salt region, as a function of rainfall (in mm/year) in that same region
The diagram indicates the two means (production, at 110,000 tons/year) and rainfall, at 1281 mm per year).

technology *salinas* than in the more modern salt production plants. A simple look at the data shows the negative correlation between rainfall and salt production. This activity, unlike agriculture, benefits greatly by the occurrence of droughts.

The data show that, indeed, sunshine and droughts are favorable to salt production, whereas rains and floods are its worst enemies. This means that, everything else being equal, salt-pond production will increase with an increase in the number of hours of cloudless sunshine and will decrease with an increase in the number of cloudy days or, worse, the amount of rainfall or, worst of all, the occurrence of floods. Thus, cloudy days depress the rate of evaporation, rain furthermore dilutes the evaporating brine, and floods top off the damage by washing away brine as well as piles of finished salt.

While the above proposition is intuitive, it is bolstered by circumstantial evidence. For Ceará, there is an almost straightforward inverse relationship between yearly rainfall in the salt-making regions and yearly tonnage of solar salt produced (cf., the scatter diagram in fig. 6). On the other hand, statistical analysis shows a consistent inverse correlation between salt production and rainfall (Table 9). In other words, droughts favor salt production, while rains and floods cause salt production losses.

Table 9
Coefficients of correlation
Salt production (tons/year) x rainfall (mm/year)
Major salt-producing regions in Ceará
(1970-1986)

Region	Coefficient of Correlation
Aracati	-0.3536
Camocim	-0.3365
Chaval	-0.7662
Fortaleza	-0.5574
State of Ceará	-0.5207

Source: Soares and Cartaxo, op. cit.

Technology, Entrepreneurship and Capital

In questioning why some regions, like Ceará, are more sensitive to climate variability than others (like Rio Grande do Norte) one has to look for other factors that influence salt production activities. It is not the case that salt production in Rio Grande do Norte is not sensitive to climate. In 1985, for example, a year of big floods, production fell 56% in relation to the previous year. But, in general, it is much less sensitive to small "normal" climate variability. From 1983 to 1984, salt production even increased 18% in Rio Grande do Norte, while having decreased by almost 70% in Ceará.

Indeed, the history of salt production in Rio Grande do Norte was different from that of Ceará. While in this latter state, production was based on local capital and entrepreneurship and did not take care, until recently, of modernization. In Rio Grande do Norte, the capital and entrepreneurship from abroad was attracted, and so the access to more investments (private as well as public) and technology.

In the 1960s, the general conditions for salt exploitation were similar and typically traditional in both states. In that decade, the solar-salt activity in Rio Grande do Norte was as sensitive to climate as Ceará's. The implantation of a modern salt-extraction system in Rio Grande do Norte in the 1970s, incorporating a high degree of mechanization and high labor productivity, was followed by a significant increase in the number of plants and a fall in employment.

Indeed, the Rio Grande do Norte salt ponds and their stores of salt became more sophisticated and better protected against the rains. A higher degree of modernization for Rio Grande do Norte's exploitation and storage system generated more resilience of the salt industry to the hazards of climate variations. The incorporation of technology in pond design and location, operations and equipment characteristics and industrial management, as well as in storage and transportation, resulted in higher productivity and diminished risks to salt production.

The incorporation of new technology and its capitalization was made possible by renewed entrepreneurship and government support. Beginning in the 1960s, the Rio Grande do Norte activity began receiving investments from enterprises located in the modern industrial cluster of São Paulo, associated with capital from abroad as well as local capital. In the 1970s, Rio Grande do Norte production was already under the responsibility of Dutch, Italian and American private groups. At the same time, in Ceará there had been no such modernization. When the high level of climate variability of the 1970s struck the two states, the salt industry in Ceará was unable to face the competition of Rio Grande do Norte. This was catastrophic for Ceará's solar-salt production activity.

Government Intervention

There are indications that government intervention has contributed to the stimulation of salt production in those areas which have shown more ability to respond to market mechanisms, as is the case of Rio Grande do Norte (as opposed to Ceará). For several decades, the solar-salt market was regulated by federal law. In 1940 the Brazilian Salt Institute (IBS) was created. Each *salina* had its prices, market quotas and target markets stipulated by the IBS. In 1965, the National Bank for Economic Development (BNDE) created a Working Group to study the role of salt as an industrial input. This Group recommended to offer salt producers of Rio Grande do Norte financial and technological support to expand their activities. Their proposal encompassed the principle of reserving for Rio Grande do Norte the captive market represented by the industrial sector that used salt as an input, while the other salt suppliers should attend to the scattered local and regional demands of households and animal consumption.

In 1967 the IBS was phased out by the Federal Government and in its place an Executive Salt Commission was created, whose aim was to plan and coordinate solar-salt related activities. This commission, which regulated activities related to production, storage, trade and industrialization of salt and was engaged with technical studies and statistical series of the solar-salt activity, was phased out in 1986, without a replacement. As a consequence, sources of information on solar salt are now dispersed and the activity is much less regulated than before.

Another aspect of the government intervention in this industry was the creation of special infrastructure for handling salt production in Rio Grande do Norte. In the 1970s, the federal government built a special harbor in this state to facilitate the trade of salt. Meanwhile, in Ceará the infrastructure remained obsolete. As a consequence of all these differences, many of the *salinas* of Ceará went bankrupt. Of 64 *salinas* in 1960, only 32 remained in 1985, and these were small-size salt plants, using traditional technologies, operated by individual entrepreneurs. For their part, the *salinas* of Rio Grande do Norte, although few in number, were large-scale plants organized as capitalist enterprises. As a matter of fact, Ceará's salt industry has begun to experience some revitalization since the second half of the 1980s, and some industries are initiating a process of modernization.

Conclusions

The solar-salt industry is highly vulnerable to extreme meteorological events. Droughts favor salt production, and hence employment and income derived therefrom, and rains and floods are responsible for drastic drops in salt production, especially in the traditional *salinas*.

The best way to increase the resilience of the salt industry in the face of a variable and possibly changing climate is through modernization, capitalization and the introduction of appropriate technologies in the production, storage, handling and transport sectors. Comparison of the case studies of Ceará and Rio Grande do Norte showed clearly that, while the former remained much more vulnerable to climate variations, the latter became more resilient after modernization of the activity.

In the case of Ceará, there are favorable possibilities for the development of the salt industry, provided it undergoes a modernization aimed at production for human and animal consumption as well as for industrial uses.

It is possible to reduce the negative effects of floods on salt production. The problem is not dependent, however, on the supply conditions. The experience in Ceará has shown that, when the expansion phase (as in drought years) coincides with times of good performance of the national economy (high rates of GDP growth), the increase in salt production is greater than when the national economy suffers a recession.

Finally, the idea that, unlike farming, salt-making thrives in rainless seasons and, thus, may provide a counter-cyclical employment factor, absorbing unskilled labor displaced from farms by droughts, is intellectually challenging but unproven in practice. For instance, figures indicate that total employment in Ceará's salt-producing establishments ranging from a peak of 1,238 (in 1970) to 802 (in 1960). These are small numbers indeed, especially when compared to the numbers of unemployed rural workers during droughts.

Photo by Carlos Namba/Abril Imagens

Pantanal/Great Swamp

Chapter **13**

THE EFFECTS OF FLOODS ON THE GREAT SWAMP[24]

Introduction

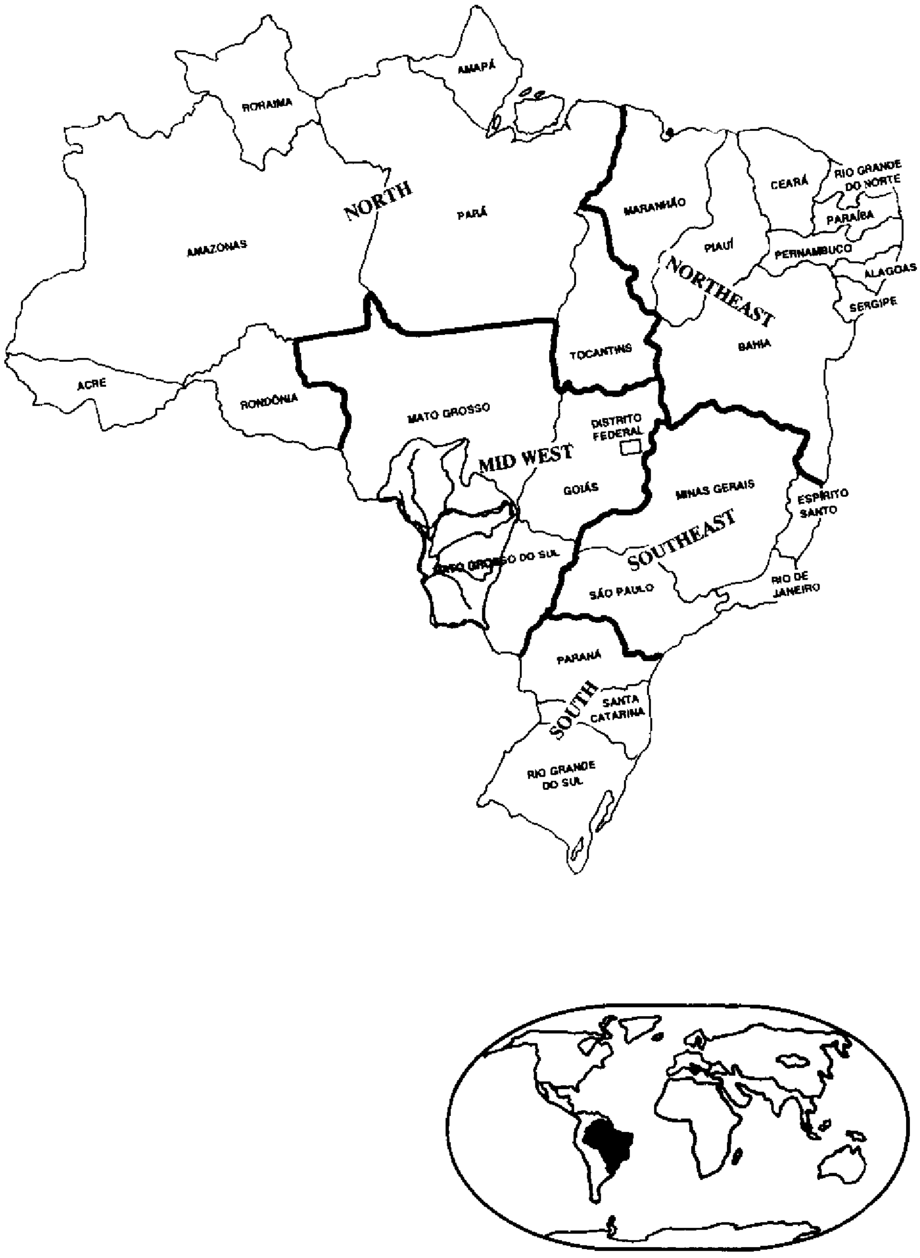
This chapter assesses the impacts of floods on the Great Swamp of the state of Mato Grosso, in Midwest Brazil. Different from other areas, like Rio de Janeiro where the floods are mainly a result of inadequate land-use practices and cause immense social, economic and environmental losses, in the Great Swamp the floods are a component of natural environmental processes and play a very important role for the long-term equilibrium of the region. There are, however, similarities.

Anthropogenic actions that result in damage to the natural vegetative cover, such as the annual, uncontrolled fire-clearing of the Paraguay River Basin's highlands, have been a cause for the acceleration of erosion processes that in turn deplete the soil, diminish groundwater retention, raise the levels of fast-flowing tributaries, and increase the influx of sediments capable of impairing the region's natural ecological balance.

The chapter first presents a description of the Great Swamp and the larger Paraguay River Basin, and then provides information on the pattern of floods and droughts as well as recent anthropogenic activities. The effects of floods on the ecology, economy and society are discussed.

24 Based on Moysés dos Reis Amaral and Paulo Shiguenari Kanazawa, "The Effect of Floods on the Great Swamp of Mato Grosso." In Magalhães and Bezerra Neto, op. cit.

FIGURE 7 - Paraguay River Basin



Regional Characteristics

The Great Swamp or Pantanal

The Great Swamp (or Pantanal, as it is called in Brazil) is one of the world's largest interior plains, occupying the central area of the Upper Paraguay River Basin (UPRB) (Figure 7). Its total area is 233,000 sq. km, of which a little over one-half belongs to Brazil (the states of Mato Grosso do Sul and Mato Grosso) and the rest divided between Bolivia and Paraguay. Studies of the geology of the plains and swamp have shown the lack of characteristics typical of a usual swamp genesis. It is a plain formed by inter-riverine lands subjected to alternating periods of floods and ebbs; these have been observed since 1900, when the first readings were taken at the Ladario station. It is an alluvial plain, sedimentary and quaternary, in the process of filling with debris. Its features include such natural factors as a continuous topography, low angle of slopes and isolated elevations. Due to these factors and to its central position within the South American continent it represents one of the world's largest ecological reserves, an ecosystem in equilibrium through complex, largely unknown mechanisms.

Of low latitude, varying between 80 m and 150 m above sea level, surrounded by tiers of foothills, depressions and plateaus up to 1,200 m high, the region is by its very nature the recipient of water, solid particles and nutrients which descend through rainfall-induced floods, and constitute the bases of its biological productivity.

Its sediment layer ranges from 75 to 420 m thick, according to drillings performed in the area of Porto Murtinho. This indicates the depth of the crystalline foundation and suggests that the area has undergone a subsidence that permitted the formation of such thick layers of sedimentary deposits.

The Uruguay-Paraguay River Basin encompasses 30 sub-basins made up of 560 rivers that drain its waters toward the plains of the Great Swamp; there, the tributaries of the Paraguay River come together, especially on its left bank. Indeed, the Paraguay River becomes the regional base-level of the Great Swamp's river system. It flows for 1,800 km until it is joined by the Apa River. It is fully navigable from the town of Cáceres to that point of confluence, a distance of 1,313 km.

The area of its influence contains a large body of water, crossed as it is by rivers, lowlands, outlets, lakes, "bays", island-separated river branches that wind around small hillocks, floodplains punctuated by hills and inselbergs, flats and bogs.

The Great Swamp is indeed a very diversified region, encompassing 12 different kinds of swamp whose environmental conditions are determined by the specific characteristics of the Paraguay River, since this river is the major artery of the Swamp's drainage system.

The Upper Paraguay River Basin (UPRB)

The total area of the Upper Paraguay River Basin covers 496,000 sq. km. It borders in the north on the Amazon Basin via the Pareci, Serra Azul and Guimarães heights; toward the east it shares waters with the Paraná Basin; in the south it adjoins the Republics of Bolívia and Paraguay; in the Southeast it is delimited by the Maracaju mountain chain.

The UPRB is located entirely within tropical latitudes and remote from any maritime influences, although the Amazon Basin to the north is its great source of water vapor. The region has two well-defined seasons: the rainy summer and the dry winter. Summer is the season for much heat and heavy rains (November through March). In the summer the dominating air mass is Continental Equatorial (CE), which originates in Amazonia and penetrates the entire region with high temperatures and high humidity. The Continental Equatorial originates from heated areas, covered with forest-type vegetation. During the rest of the year the, Atlantic Tropical (AT) dominates, coming from the Atlantic. August and September witness the great heating effect of the soil, causing hot air to rise and carrying with it solid particles as well as smoke from fire-clearing, up to an altitude of 4,000 meters. Around this time the CE that advances on the Great Swamp pushes the AT towards the South and East, triggering the formation of dry fog (dry mist) over the region. The period is marked by poor visibility for aviation purposes as well as by muggy, moist weather.

With respect to temperatures, annual averages are 23-25°C. Maximum temperatures exceed 45°C, minimum temperatures reach

0°C. The hottest areas are located in the Great Swamp. Evapotranspiration in the area ranges from 1,000 to 1,400 mm per year; rainfall from 1,000 to 1,200 mm per year in the plains, 1,600 to 2,000 mm per year on the surrounding slopes. With regard to the regional water balance, there is excess in the uplands and deficit in the lowlands.

In the case of the Great Swamp specifically, there is the greatest concentration of heat with low atmospheric pressure in forming an internal cyclone zone, that contributes to the summer rainy season, although not enough to create a water excess. Instead, its deficit is above 300 mm per year. The plain, thus, receives the water reserves accumulated from the Basin's total.

Land Use and Anthropogenic Activities

Explored by the Spaniards in the first half of the 16th century and by the Portuguese in the 18th century, the region only began to be settled in 1775. For the next 200 years, the region was known and admired primarily by explorers and by those who came to take advantage of its economic potential. Only in the last 15 years has the region become widely known as the globe's largest base-level interior plain, harboring an ecosystem with its own unique fauna and flora.

The area of the Great Swamp is not very appropriate for agricultural purposes. With the region's humid area and immense stretches of natural pasture, however, cattle-raising represents its economic mainstay. Land-use occupation has been based on huge landholdings, where herds are created extensively; indeed, many of them used to be wild herds that were "captured" and appropriated by the landholders. Total herds amounted, in 1988, to about 3.9 to 6.0 million heads, according to different estimates. Growth of these herds and successful cattle raising in general depend on the regimen of floods and ebbs.

With respect to human population in the Great Swamp, about 200,000 people inhabit the region. They are farmers, cowboys, rural workers and fishermen. (The data refer only to the Brazilian sector of the Great Swamp, or about 150,000 sq. km).

Expansion of the Farming Frontier

The water regimen in the Great Swamp is very much influenced by what happens in the Upper Paraguay River Basin. This Basin maintained its ecological integrity until the 1950s, when the farming frontier reached its borders, accompanied by the building of access roads in its eastern, northern and northwestern parts. Along these roads, farming centers appeared which grew into the towns that today mark the entire Basin.

In the 1960s and 1970s, several regional development programs were promoted by the Federal Government in the UPRB region. Such government support triggered a population increase that reached an annual growth rate of 5.7% during the 1960-70 period, as opposed to 2.9% for Brazil as a whole. In 1986, the regional population reached 2.1 million inhabitants, almost double that of 20 years earlier. Most of the economic activity concentrated on farming, with the settlement of large tracts in the plateaus and depressions surrounding the Great Swamp plains.

The advancing frontier has caused violent changes in the natural vegetative cover of the entire river basin, including the Amazonian forest in Mato Grosso's north, as a result of uncontrolled land clearing and slash-and-burn agriculture. Such aggressive action against the environment has increased at a frightening rate.

The alteration of the environment in the upper part of the Paraguay River Basin may have significant consequences in the Great Swamp. As stated in a report by the Brazilian Institute for Forest Defense (now the Brazilian Environment Institute - IBAMA); "The annihilation of large tracts of the original vegetative cover can cause disturbances in the physical domain (water and heat balance, climate, soil structure, winds) as well as in the biological sphere (destruction of many forms of life), with unforeseeable consequences for human habitability".

Indeed, there has been some concern about the most recent cycle of floods which has been continuing for 14 years, with water levels still rising, probably as a consequence of human activities. The water level of the Great Swamp has remained high for a relatively long time.

Climatic Events in the Study Area

Droughts in the Great Swamp

The word "drought" raises images of water shortages, parched fields, and heavy economic losses in farming and cattle raising. It is tantamount to poverty and suffering in the affected regions.

In the Great Swamp, droughts are green because there is water, assured by rivers and groundwater. Annual dry seasons do not cause major problems because they occur in the winter and spring, after which the summer rains start. Records show that droughts lasting for several years were rare before the 1960s. When the waters are low in the dry season, the Great Swamp thrives because there are more pastures and dry resting spots. Allowing herds to grow to impressive numbers proportional to the length of the drought: almost 7 million head from 1964 to 1973. For the population, too, the advantages are obvious. Job openings on farms increase and wages go up. Farm production and farm populations rise, and produce is plentiful and cheap in the towns.

Floods in the Great Swamp

Over the last 88 years, the water level of the Paraguay river, as measured at Ladário, has exceeded 4 meters (the alarm level as defined by the government) in about 60% of those years. Thus, the Great Swamp floods are a fact of life, and determine the amphibious nature of the region (about twice each year there is a switch between terrestrial and aquatic biotypes). As shown in Table 10, there are three main types of floods in the Great Swamp:

a) Ordinary Floods: small, reaching 3-4 meters. During the last 88 years, they occurred 34 times;

b) Intermediate or Extraordinary Floods: regular, frequent; if there are areas for its discharge, they supply surface and subsurface natural reservoirs; they are beneficial and do not cause social or economic upheaval, reaching 4 - 5.5 meters. They occurred 42 times;

c) Exceptional Floods: very infrequent; have serious social and economic consequences; in addition to large overflow areas, they submerge pastures and reduce dry rest areas;

serious consequences due to the delayed water drainage and to evapotranspiration mechanisms; they reach 5.5 - 6 meters, and more. Flooding above 6 meters occurred eight times in the last 88 years.

One must conclude that the equilibrium condition of the Great Swamp's ecosystem consists of intermediate floods.

Table 10
Floods in the Great Swamp
(Average high-water and duration)

Hydrological Year	Average high-water	Number of Days Over 5 m	Over 4 m	Over 3 m
1904-05	6.62	152	229	272
1951-52	4.64	—	89	171
1973-74	5.46	63	127	230
1976-77	5.54	107	200	270
1987-88	6.64	139	199	337

Between the hydrological years of 1899-1900 and 1963-64 there were floods for two 4-year periods (1920-23 and 1930-33) and one 6-year period (1956-61), interspersed with one 4-year drought period (1936-39) (see Table 11).

In the 1960s oscillations began to appear that clearly exceeded what had previously been recorded, with longer unbroken sequences of droughts and floods, and with high-water marks that reached both a new low (1.11 m in 1970-71, a year in which the flow rate was so poor that the low-water mark fell to -0.5 m) and a new high (6.64 m in 1987-88, breaking the 6.62 m record set in 1904-05).

In 1970-71 the low-water mark continued for 365 days below 2 meters (304 days below the 1 m mark, setting off warnings to shippers). That was part of a 10-year drought that started in 1963-64, when the high-water mark was 1.62 m and the highest low-water mark -0.61 m; there were 366 days below 2 m and 325 days below 1 m. The longest and most impressive period of floods ever recorded in the Great Swamp began in 1973-74 and continued for 14 years.

In the 73 years that records have been kept at Ladario, readings between 5 m and 6 m have occurred on 20 occasions, while levels above 6 m occurred in only three years. Yet, during the last 14 years,

Table 11
The Great Swamp
Flood Years and Drought Years
(1900 - 1988)

Decade	Flood Years	Drought Years
1	1900-02, 1904-06	1903, 1907-09
2	1912-13, 1917	1910-11, 1914-16, 1918-19
3	1920-23, 1926-27, 1929	1924-25, 1928
4	1930-33, 1935	1934, 1936-39
5	1940, 1942-43, 1945-47, 1949	1941, 1944, 1948
6	1950-52, 1954, 1956-59	1953, 1955
7	1960-61, 1963	1962, 1964-69
8	1974-79	1970-73
9	1980-88	

Source: Ladario Monitoring Station.

there have been six 5-6m recordings and five readings above 6 m. This strongly suggests changes in the water flow caused by human activities as a result of modifications in the natural vegetative cover in the tributary area outside the plains. The removal of tree cover in the adjacent areas has also triggered erosion, a drop in underground water storage, and higher effluent levels in the rainy season. These factors in turn increase the flow of sediments, altering the alluvial cones of the rivers, thereby upsetting the drainage system and extending water residence time within the Great Swamp.

Indeed, the indiscriminate removal of the natural vegetative cover within the main subbasins is accelerating the process of erosion. It should also be made clear that the destruction of the Amazonian forest north of the basin might cause changes in the air masses formed by the Continental Equatorial air mass that predominates during the summer. This could affect rainfall in the headwaters of the Paraguay River.

The Impacts of Climatic Variability

Ecological Impacts

Together with the headwater regions, the floods are responsible for the fertile deposits on the flooded areas — a system of "delayed passage" of the alluvial matter which, after several uses, is carried to the Paraguay River. Floods are also a factor in the renovation of the vegetative cover, particularly in the *campo limpo* type savannas, in floodprone fields, flat depressions, bays, woods, savannas and border forests. An extraordinary restoration of grasses, legumes and other natural forage also occurs.

Conversely, the floods eliminate many harmful weeds that invade the fields during prolonged droughts. They perform an extraordinary cleansing action on the pastures, functioning as suppliers of the ecosystem's aquifers that ensure soil moisture. The moisture in turn requires that living matter adapt to these peculiar ecological conditions, in a constant struggle to ensure its survival. Life in the "delayed-passage type" ecosystem can only be sustained if there is a constant balance between inflows and outflows. Thus, flooding is responsible for the renovation of the Great Swamp's typical fauna and flora.

Economic Impacts

While the ecology is rejuvenated by the floods, the economy undergoes great hardships because of the downturn in cattle raising. As explained earlier, the latter is the economic mainstay throughout the Great Swamp area. Range areas are greatly reduced by the floods. As a result, cattle crowd around the flooded areas and often enter them in search of forage. The pastures on hilly terrain are soon overgrazed, while the high waters remain because of slow drainage. Consequently, an imbalance occurs between herds, pasture and available dry resting spots.

Herds suffer great losses, particularly if an exceptional flood shortly follows an intermediate flood. Under such conditions, the total number of consecutive high-water days increases. Losses principally include deaths due to drowning, temporary loss of pastures, and livestock deaths resulting from cold weather that decimates weakened herds.

Exceptionally high water levels (above 6 meters) always cause unpredictably high economic losses, since they are generally accompanied by cold fronts which further increase cattle deaths. Even after the water recedes, there is a shortage of pastures because of the after effects of prolonged inundation. Thus, losses continue for some time, particularly of calves. During the 1988 flood, losses amounted to 20% of the total herds, although much of the cattle had been driven in time to higher country.

In addition to cattle deaths, there are great losses caused by damage to infrastructure such as fences, corrals, gates, wells of all kinds, troughs and salt licks. One estimate by the state agricultural research agency of Mato Grosso suggests that the depreciation of the value of infrastructure items increases from 5% in normal years to 15% in years of exceptional floods.

Social Impacts

The Great Swamp region is settled but not farmed. As a result, there are no cities, because of its swampy nature. There is, however, a large and extensive cattle-raising industry that features a herd density of 41 head per sq. km, compared to a human density of less than 1.5 person per sq. km. The human population is distributed over farms and outlying stations, as well as isolated dwellings close to river banks.

When floods occur, a large part of the work force is "released" because there is little work for it to do and the cattle owners are short of money. Furthermore, the self-employed population close to riverbanks, making a living by subsistence farming and fishing, hunting, bee-keeping, and so forth, is dislodged by the high water and seeks refuge in neighboring towns. There, the refugees find temporary shelter with relatives and seek government aid, since they have no means of their own. They live in destitution until they can return to their former abodes. The longer the duration and more frequent the floods, the more acute the problem.

Since there have been 15 major floods within the last few years, many otherwise unemployed people have been hired by poachers and smugglers of pelts, skins and birds. One of the adverse effects of their illegal activities has been the decimation of some species such as alligators and the disruption of an ecological balance with piranhas. In fact, the mounting numbers of such skin-smuggling outlaws have become a threat to the public.

Conclusions

- This study suggests that there is a tendency toward instability of the Great Swamp ecosystem caused by farming in the uplands, with alarming changes in the natural vegetative cover.
- Due to the unique nature of the region, unlike most other places, droughts in the Great Swamp result in increased production and beneficial economical and social consequences, at least in the short term.
- While floods do not bring the public calamity they often do in other parts of the world, although they do cause losses to those engaged in the cattle-raising industry.
- There is a need for additional research on which to base the development of regional sustainable development strategies. This research should cover not only the Great Swamp, but the whole Upper Paraguay River Basin of which it is a part.

Chapter **14**

THE EFFECTS OF FLOODS IN RIO DE JANEIRO[25]

Introduction

It will be some time before the people of Rio de Janeiro forget the summer of 1988. Instead of the festive spirit that traditionally marks the first warm months of the year, violent changes in the weather brought about a great deal of suffering.

Starting at the beginning of February 1988 and continuing intermittently until after Carnival (17 February), rains assumed deluge proportions, with some areas experiencing the equivalent of three months' rainfall within a 24-hour period. The extent of death and destruction was staggering: about 300 dead, more than 1,000 injured, thousands left homeless, and damages estimated to be in the one-billion-dollar range.

At the time it was founded in the 16th century, Rio's geographical features — lagoons, swamps, estuaries — were in ecological balance with the rainfall and physical relief patterns. Over the centuries, as settlement of what today is referred to as the Metropolitan Rio de Janeiro Region (RMRJ) proceeded, the forests were cut down and the marshes and lagoons filled in. No provisions were made to accommodate the paths of the natural flow of water. With the resultant imbalance in natural conditions, rainwater runoff erodes the steep hills that surround the city, carrying the debris downslope, until it reaches the sea. The effects of this process are magnified whenever particularly heavy rains occur, often resulting in human tragedy.

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25 Based on Luiz Roberto Azevedo Cunha, Márcio Miller Santos and Josué F. de Castro Filho, "An Integrated Program for Flood-Damage Reconstrution and Prevention: The Case of The Metropolitan Region of Rio de Janeiro." In Magalhães and Bezerra Neto, op. cit.

FIGURE 8 - Metropolitan Region of Rio de Janeiro City

The unplanned expansion of human settlement and the lack of investment in basic infrastructure such as drainage systems, sewage and waste disposal facilities, and roads and housing have exacerbated the impacts of extreme meteorological events. Without integrated governmental action to prevent the floods, the pattern of death and destruction has tended to repeat itself with ever-increasing severity and heavier human losses.

The purpose of this study is to evaluate the physical and socioeconomic characteristics of these events, to examine their causes, and to describe a proposed government response program.

The Affected Areas

The most important features of the affected areas are their topographical characteristics, especially their hydrographic basins, drainage conditions and weather variations. From this perspective, such areas can be subdivided into three subregions:

1. The subregion nearest to the coast stretches from the sea to the back of Guanabara Bay and includes the municipality of Rio de Janeiro. It features a coastal mountain range, cut transversely by passes that lead down to small plains and coastal lakes. Among these mountains — which have suffered from a great deal of deforestation and whose slopes have been settled by squatters' slums (called favelas) — the Maciço da Tijuca stands out, because of its particularly high population density and by the fact that it was hard hit by the rains. The part of this subregion that is closest to Guanabara Bay was once swampy, but over the centuries has been drained and is now the city's downtown business district and, further along, the dock area.
2. Further inland there is the Baixada (lowlands) Fluminense subregion, bounded on one side by the city of Rio, and on the other side by the southern slope of the mountains. This region was originally marshy, with an extensive hydrographic basin. The first drainage projects in this area were undertaken to permit the planting of sugar cane in the 17th century. The largest project took place between 1936

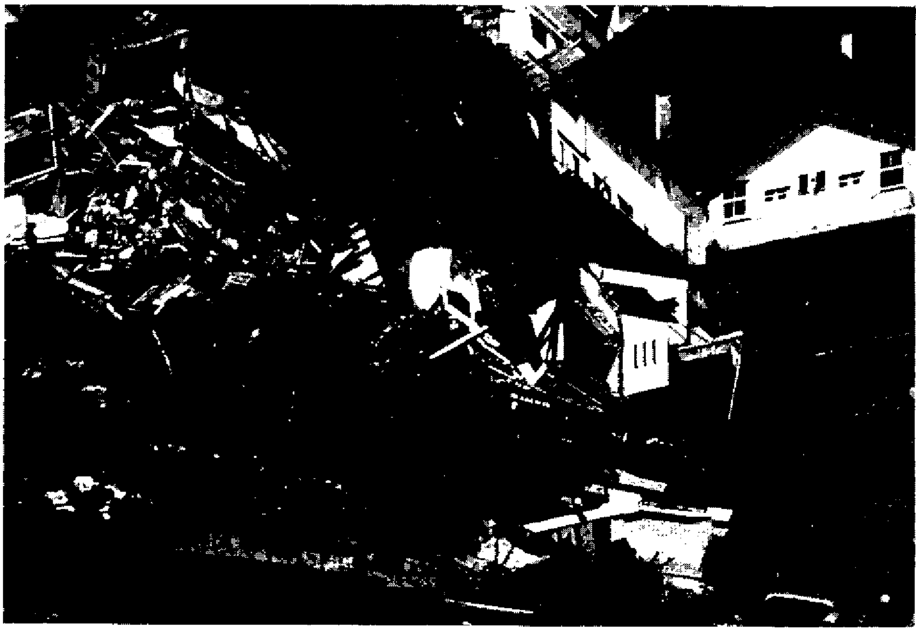

Photo by Flávio Rodrigues/Abril Imagens

Inundações/Flooding (Rio de Janeiro)

and 1945, including canal cleaning, river dredging, and construction of canals and dikes.

3. The third subregion is high up in the Serra do Mar mountain range and is characterized by steep hillsides and deep valleys, among the latter those that form the Palatinado and Quitandinha Rivers. Both these rivers are tributaries of the Piabinha River, joining in a canal cut through the downtown area of the city of Petrópolis. The canal's low drainage capacity is a cause of frequent flooding in the area. The hillside soils are generally shallow and vulnerable to erosion. The downhill movement strips off the top layers which have been formed by the decomposition of the rock.

In terms of rainfall, the entire region is characterized by two alternating seasons, a dry winter followed by a rainy summer, with particularly heavy rains in February and March.

Of the original green vegetative cover, the so-called Atlantic Forest (or Mata Atlântica), little remains today. In its original state, the heavy vegetation furnished an excellent defense against erosion and landslides resulting therefrom. Over the years, constant deforestation and uncontrolled settlement of the land have left a few isolated vestiges of the original forests on the slopes of the Serra do Mar, at the summits and ridges of mountain ranges, and in the protected, second-growth forests such as Tijuca National Park.

Socioeconomic Aspects

The total population of Rio de Janeiro is about 14.1 million people (1990). Its population density as well as its rate of urbanization are the highest in Brazil. Metropolitan Rio accounts for 80% of the state's population and 77% of its total income. In the state as a whole, only 2% of the population lives in rural areas. Most municipalities of the metropolitan region are completely urbanized.

In Rio de Janeiro there are about 3 million dwellings (1990). According to the 1980 Census, 59% of the dwellings in that census year were located in the municipality of Rio de Janeiro and 23% in the Baixada Fluminense. This percentage surely must have increased since that year. The average number of inhabitants per dwelling varies between 3.9 to 4.5, according to the municipality.

Eighty-two percent of metropolitan Rio dwellings are provided with running water. As far as sewerage is concerned, 77.4% are either connected to city sewers or have septic tanks. 600,000 dwellings have no indoor plumbing facilities of any kind. Baixada Fluminense lacks a separate sanitary-sewer system, as distinct from a storm-sewer system.

Economy and Income

Besides being a world-renowned tourist attraction, the city of Rio de Janeiro is also Brazil's financial heart. Many governmental activities are centered there, including the head offices of the country's largest state-owned companies. Since Rio lacks any significant agricultural or manufacturing operations, its major employers are commerce, finance and services in general (accounting for 73% of all jobs). Due to the absence of enough demand for unskilled labor, Rio also has a lively informal economy.

Settlement Patterns

Settlements on urban hillsides and on river and canal banks are two characteristic developments of metropolitan Rio de Janeiro land occupation within the past few decades. Of the various forms of uncontrolled land use, the expansion of hillside slums is among the most insidious. The rural exodus that started around the turn of the century resulted in large numbers of poor who, due to the high cost of land and the lack of public transportation, had no option but to become squatters on city-owned hillsides, close to whatever jobs they managed to find.

By 1937, when the City Building Code went into effect, the number of squatters was already alarming. The Code stipulated that slums were to be replaced by low-income housing projects, the first of which was built by the local government. Although similar programs were carried out in the 1960s and 1970s, the number of slums continued to grow. In fact, the projects started to deteriorate and, eventually, they too became slums. The number of slums increased, so that in 1980 12.3% of the Rio population lived there.

At present, all of the municipalities considered in this study have land-use codes containing zoning restrictions. These take into account present and future use, as well as physical features such as slope and vegetation. However, these laws are neither strictly obeyed nor enforced. This is particularly true in the case of environmental protection restrictions which are generally ignored because of real-state interests.

The poor are forced to squat on steep hillsides or areas subject to flooding or else seek areas in outlying districts. The result is either the deterioration of the environment or the creation of great, if not insurmountable, difficulties for government in providing basic urban services. Rio de Janeiro's expansion tends to proceed in the direction of the Baixada Fluminense and towards the municipality's western zone. Lots are sold in installments at relatively low prices. Generally devoid of utility services, the dwellings are built over an extended period of time by their owners, who live in them during construction. The same system prevails in the Baixada subregion.

In Petrópolis, the expansion process took slightly different forms. There, the fact that industrial buildings pre-emptied most of the level areas forced rich and poor alike to resort to homes built on the steep hillsides, since the region's narrow valleys were already occupied. The result was deforestation, erosion and consequent landslides.

The Great Flood

The heavy rains of February 1988 were caused by a cold front which, while moving across the coast of Rio de Janeiro in a northwesterly direction, became stalled when it met a mass of tropical air coming from the Amazon basin and moving in the opposite direction. In this situation, the local topography, which normally serves as a barrier to the penetration of air masses, acted to stall the weather system over the area.

The intensity of the rainfall during that period may be gauged by comparing prior average figures for the region with the amounts recorded during the period in question. Thus, at the downtown Petrópolis weather station, the historical average for February was 237.2mm; between January 30 and February 6, 1988, 414mm of rain fell on Petrópolis; for February 1-24, the figure was 776 mm.

Table 12
Rainfall Recorded at Selected Weather Stations
Rio de Janeiro
(mm)

Weather Statione and Location	February Average	February 1988	February 2, 88	February 19-22, 88
Praça XV, Downtown	147.7	443.4	30.0	199.5
Aterro, Southern Zone	78.5	435.6	3.7	214.1
Alto, Tijuca	228.2	634.2	—	245.5
Santa Teresa, Tijuca	174.2	610.8	28.6	321.8
Bangu, Western Zone	165.5	673.0	54.8	123.4
Jacarepaguá, Western Zone	162.2	373.4	40.0	103.6
Santa Cruz, Western Zone	158.8	521.9	140.0	109.3

Source: National Meteorological Institute, Sixth Meteorologic District, Rio de Janeiro,1989

The following table provides comparative data for normal rainfall against February 1988 figures, selected from the recordings of several weather stations in the city of Rio de Janeiro.

Physical and Human Impacts of the Floods

The violence of the natural downpours combined with accumulated human errors such as lack of or inadequate land use planning and failure to invest in needed infrastructure, to produce tragic consequences.

The phenomenon was not new to Rio. Heavy rains have caused landslides ever since the settlement of the city began. For example, there were serious occurrences in 1759 and 1811 in the downtown area. There were landslides in the 1940s. In 1966, after a torrential January rain, landslides destroyed a great number of houses and caused over 100 fatalities. Other material damage was extensive, including the breakdown of the water, power and sewer network and the interruption of major thoroughfares. In February of the following year, events followed a similar course with fatalities twice as high.

In Petrópolis, problems caused by rains, floods and landslides were also part of the city's history. Although on a smaller scale, incidents similar to those of 1988 had occurred during the 1960s and 1970s, with the most recent one occurring in 1981. Yet, in spite of warnings, human occupation of the hillsides proceeded, and no slope-stabilization work was carried out.

In Rio de Janeiro, the city's hardest hit parts were the slopes of the Maciço da Tijuca mountain range, where a majority of the recorded 90 or more landslides took place. In addition to causing human fatalities and material destruction, the rains also made it necessary to evacuate many houses, generally slum dwellings built in precarious locations.

Sudden landslides, together with the slower downward movement of eroded soil and accumulated trash from the hillside slums, plus the enormous volume of runoff from the downpour, combined to destroy a great part of the city's road and sewer systems and to obstruct important canals, thus causing flooding in densely populated areas.

The low-lying part of Rio that was marshlands until it was reclaimed by draining includes a square called Praça da Bandeira, which is a major link between downtown and the northern districts, and an avenue called Avenida Brasil, which is the city's main thoroughfare (with a daily traffic of 200,000 vehicles). Both were totally flooded, cutting Rio off from outlying western suburbs and from highway connections to the rest of the country.

In the Baixada Fluminense, a number of factors contributed to aggravate the flooding of many densely populated areas: a lack of maintenance of storm sewers; buildings constructed on river banks and even river beds; and the lack of an adequate trash-collection system. The flooding destroyed access roads, buildings and property, interrupted economic activities and left more than 15,000 people homeless.

The situation created conditions favorable to the development of vectors of such contagious diseases as leptospirosis, spread by contact with rat urine. The reported number of such cases increased from 15 for the year 1985 to 1,039 in March 1988, causing 35 deaths.

To add to the region's woes, the already precarious drainage system of the Baixada Fluminense was severely impaired, so that even the less severe rains that fell in subsequent weeks caused almost constant flooding.

In Petrópolis, the rains caused the entire region's largest number of fatalities, the flooding of the downtown office and shopping district, landslides and destruction of dwellings, and electric power failures. To these must be added the problem of physical isolation due to landslide-blocked access roads.

A great number of public buildings, including 150 schools, were damaged within the metropolitan Rio region. The school problem was further aggravated by the fact that many other school buildings were used to house the homeless.

Among the 3,000 storm-related events recorded, the following stand out: 156 buildings totally collapsed, 85 partially collapsed, 425 were in danger of collapse, 845 were found to have structural cracks; 521 landslides, rock slips or destroyed retaining walls and an additional 411 instances of endangered spots; 237 instances of flooding; and seven cases of dangerous-substance spills.

The Economic Impacts

An estimate of the total cost of the calamity would have to include the following: first, direct damage caused by destroyed structures such as roads, highways, bridges, dwellings, schools, health stations and other public buildings, water and sewer systems, power and telephone lines; second, the material losses caused by the flooding of factories and stores; third, the cost of the virtual stoppage of all productive operations, including by transportation systems, during a 6-day period.

Thus, an estimate of total disaster-related losses, prepared by the Rio de Janeiro state government in conjunction with World Bank experts, amounted to close to US$935 million, of which US$435 million were due to lost production, US$400 million to physical damage, US$50 million because of lost tourist revenue, and US$50 million in clean-up costs following the calamity. Economic losses would have been greater, had it not been for the fact that the worst downpours occurred during the weekends.

Government Responses

During and immediately after the floodings and landslides, authorities had to limit relief activities to emergency operations, assisting the homeless, rescuing people trapped by landslides or collapsed buildings and taking care of the deteriorating situation. A large-scale campaign was mounted asking for donation of blood, food and medical supplies, and blankets. The public was informed of the danger of contagious diseases.

When the storms abated at the end of February, it became possible to start reconstruction work. Road repair began at once. At the same time, the state and federal governments began the preparation of a comprehensive strategic attack on the problem, called the Flood-Damage Reconstruction and Prevention Program for Areas of the State of Rio de Janeiro.

The Reconstruction and Prevention Program

The program's objectives were as follows:

a) the reconstruction and rehabilitation of basic infrastructure damaged by floods;

b) physical and institutional measures to prevent and ameliorate the impact of future floods;

c) a program to provide emergency aid in future disasters.

The program integrated state government with federal and municipal agencies as well as with the private sector. The adopted measures were envisaged to also cover urban planning, land-use legislation and environmental protection needs.

The following specific items were included in the Program:

a) *Highway System.* Paving of 120 km of roads; construction of 11 km of retaining walls and related drainage; repair of 24 bridges;

b) *Drainage.* Rehabilitation and repair of river-basin drainage systems by dredging 180 km of rivers and canals; construction of dikes, drainage ditches, crossings and locks;

c) *Sanitary Sewers.* Construction of 370 km of sewers; sewer hookups to 14,630 dwellings;

d) *Solid Waste.* Construction or modernization of several garbage-processing and composting stations;

e) *Public Buildings and Installations.* Repair of 150 state and city schools; repair of aqueducts and other water supply facilities;

f) *Slope Stabilization.* Application of landslide prevention measures in 120 locations;

g) *Reforestation.* Restoration of local ecosystems on 30 hillsides comprising 1,200 hectares;

h) *Improved Lots.* Construction of 11,000 improved lots, in order to replace homes that were either destroyed during the storm or were located on high-risk hillsides;

i) *Civil Defense.* Improvement of the civil defense system, including new equipment acquisition;

j) *Technical Assistance.* Planning assistance for civil defense, reforestation and slope stabilization, improved municipal tax administration, garbage collection and environmental education.

The program preparation was concluded in June 1988, the total cost estimated at US$393.6 million. The main items included the following: drainage, 44.5%; slope stabilization, 17.4%; roads and bridges, 10.5%; improved lots (housing), 9.7%; and sewer system, 7.7%. With regard to financing, a loan from the World Bank participated with 50% of the total cost; the remainder was allocated by the Federal Government.

Final Remarks

It is important to stress that a more wide-ranging solution for the urban and environmental problems of the area would require much heavier investments, and would involve other policy matters as well as additional projects. It is suggested, for example, that in addition to the proposed program the future state and municipal budgets provide significant allocations for river-and-canal maintenance. Keeping these in good repair is essential, if future floods are to be prevented. (Indeed, heavy floods occurred again in 1990, and the area still proved to be vulnerable).

The problem of floods in Rio de Janeiro is a secular problem, resulting from the inadequate characteristics of the region's land use and, especially, the lack of environmental considerations. The program now under way is expected to yield results, but the pressure for land use is still a serious problem. Indeed, a long term sustainable development strategy is necessary to reduce significantly the risks of the Rio de Janeiro population to adverse weather-related events.

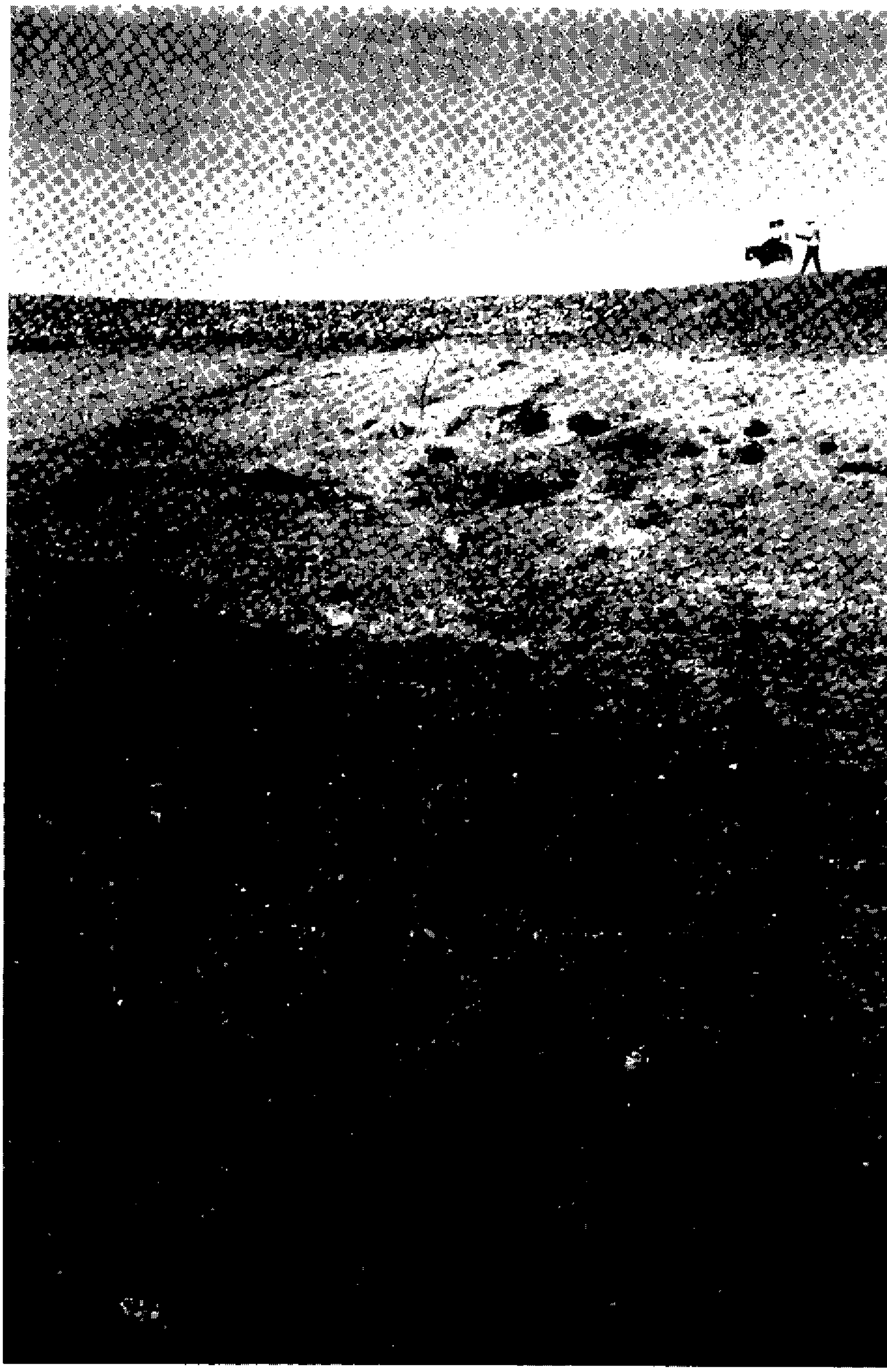

Photo by Orlando Brito/Abril Imagens

Açude de Irauçuba/Irauçuba Dam (Ceará)

CONCLUDING COMMENTS:

EXPERIENCE AND LESSONS FOR COPING WITH CLIMATE VARIABILITY AND THE PROSPECTS FOR CLIMATE CHANGE IN BRAZIL

Experience teaches us that climate variability is a very important issue, not only as a physical phenomenon but especially because of its social, economic and environmental consequences. Because of this, climate issues deserve much more importance than they have received up to now. The studies in this project show the very significant, and most of the time, adverse effects of drought in the Brazilian Northeast, as well as in other regions of the country. The agricultural sector is certainly the most obviously and directly affected by droughts, but other sectors like hydroelectric power generation are also greatly affected. Production and productivity fall, prices increase, and food shortages occur because of droughts. Floods, too, are a major problem in many regions, including the metropolitan region of Rio de Janeiro, where the consequences have been catastrophic. Freezes, in their turn, are a cause for great concern in the southern and southeastern regions, having been the cause of very great economic losses in various years. Altogether, droughts, floods and freezes have caused the loss of billions of dollars and, principally, have been responsible for considerable human suffering and death.

One problem, however, when considering climate change in Brazil, is the lack of credible scenarios of possible future climate in the country. Brazil is a large country, with regions as diverse as the

Amazon, the semiarid Northeast, the Midwest, the Southern prairies and the Great Swamp. Each region has different climate characteristics today and could have different climate characteristics tomorrow. The present knowledge of the regional dimensions of a global climate change is still very fragmented. Thus, any scenario of future climatic change for the several regions of Brazil can have a heuristic rather than predictive utility.

Today there is considerable discussion about the possible widespread impacts of a potential global warming of the atmosphere. Such a warming has been attributed to the burning of fossil fuels and to land use activities such as agricultural production, manmade chemical production, and land clearing. The particular trace gases of concern are carbon dioxide, methane, chlorofluorocarbons (CFCs), and nitrous oxides. These gases, called greenhouse gases because of their radiative properties that tend to trap heat within the Earth's lower atmosphere, are being generated by human activities at apparently unprecedented rates in a human historical timeframe. The major concern at present centers on carbon dioxide and the CFCs. Future emissions of CFCs have been dealt with effectively through the signing of an international agreement referred to as the Montreal Protocol. Today, there are negotiations for constructing an international climate convention to limit the emission of carbon dioxide. But many concerns have been raised that will tend to slow down the process leading to a meaningful climate convention in the very near future, concerns such as determining responsibility for increased atmospheric content of greenhouse gases, technology transfers required to reduce fossil fuel consumption in developing economies, sustainable development issues, and even concern about the reliability if not validity of climate change scenarios being generated by atmospheric general circulation models.

A large number of physical and social science researchers are addressing numerous issues related to this matter. One thing on which most seem to agree is the limited value at this time of the general circulation models of the atmosphere. While useful for generating hypotheses about interactions among the components of the climate system, they are less useful for the needs of regional and local policymakers. This creates a dilemma for those decisionmakers who wish to respond to the potential eventual consequences of the regional impacts of global warming.

Some observers, speculating about changes in regional climate, suggest that where droughts now occur, under conditions of global warming, they will continue to occur but with greater frequency and intensity. The same logic has been applied to the wetter regions; the frequency and intensity of floods will be enhanced by global warming.

Other observers, however, suggest that climatic zones will shift, making today's wet areas drier and dry areas wetter. Temperature increases in the tropical areas are expected to be lower than in the mid- and high latitudes. Precipitation globally will be enhanced, and so forth. In addition, sea level is expected to increase in a warmer atmosphere, rising at the low end of estimates about 20 to 40 cm in the next several decades.

Such future scenarios include higher temperatures (less in the Amazon and the Northeast, which are near the equator, and more in the South). This increase in average temperatures might mean frequent heat waves, more frequent droughts, more floods, and possibly fewer frosts. Since Brazil has 8,000 km of coast, sea level rise would adversely affect coastal cities, destroy salt ponds and inundate low lying areas near river deltas. In the end, the several areas in Brazil will be coping with the same types of climatic variability of today, but the frequency and intensity may be different (probably for the worse, in the cases of heat waves, droughts and floods). There may also occur some change in the geography of theses events, with droughts occurring in other areas besides the Northeast and so on.

It is also important to remind the reader that the climate of Brazil does not occur in a vacuum. For example, many studies suggest that the Brazilian climate is quasi-periodically affected by ENSO (El Nio-Southern Oscillation) events. ENSO events have been associated with increased drought conditions in the Brazilian Nordeste and heavy flooding in the Southern parts of the country. Thus, any speculation about Brazilian climate changes under global warming conditions must take into account considerations about how a global warming will affect the frequency, intensity, and duration of ENSO events. As of today, little attention has focused on this linkage.

For these reasons, we have resorted to the use of contemporary climate history to identify the possible strengths and weaknesses of responses to existing climate-related changes in the environment. Whether or not the climate warms, cools, or stays as it is today, it will still vary on a variety of time scales. Thus, information generated about how well we have dealt with climate conditions in the recent past can only improve our ability to face the uncertain climate conditions of the next several decades.

Many scenarios that might be generated about Brazil's climate future could be shown to be plausible. But each of those plausible scenarios would most likely generate totally different policy responses and totally different results. Thus, we approach speculation about Brazil's climate future with considerable caution, until scientists can develop a more reliable assessment of the regional detail of global warming.

A few of these lessons which will be useful in preparing for climatic change are as follows:

a) *The impacts of climatic variations differ according to the social, economic and environmental characteristics of the region in question.* For instance, droughts in the underdeveloped semiarid Northeast, constitute a very great chronic social problem, because of the high vulnerability of a significantly poor and uneducated population, whereas drought in the southern and midwestern regions bring economic losses but much less human suffering. The higher degree of vulnerability of the Northeast is attributable to the region's low level of economic development, low per capita income, skewed income distribution, fragility of the semiarid environment and the frequency and intensity of droughts. Another example of social vulnerability to climate variability are the floods in Rio de Janeiro, which have a major socio-economic impact. In the Pantanal area, extreme meteorological events are part of the ecological balance and are important for the maintenance of natural productive conditions.

b) *For the same type of climatic event, whether in the same region or in different regions, there will be winners and losers.* For instance, while the agricultural and hydroelectric sectors have been major losers in the case of droughts, the salt industry in the Northeast and the farmers and cattle-raisers in the Pantanal region have been drought-related winners. Also, in the case of droughts in the Northeast, when millions of people are adversely affected, there are those who can make a profit from the situation, in terms of political as well as economic benefits. In some cases, commerce increases, the government collects more taxes, and the services sector is enhanced.

c) *In general, human interventions that do not take into consideration the environment often increase the vulnerability of the region to climate-related hazards.* For example, Rio de Janeiro is much more vulnerable to floods today than in the past because of the pattern of land use (the deforestation and development of hillsides) and the general lack of attention to and concern for the environment. In the Pantanal (Great Swamp) region, because of substantial deforestation in the Upper Paraguay River Basin, a change in the pattern of floods produces many problems for the environment and the economy. Last but not least, patterns of land use have been a cause for decreases in productivity, depletion of natural resources and even the initiation of desertification processes in several regions. It is important to remind the reader that certain human responses to climate-related hazards have produced some benefits. For example, the relocation of coffee production from the state of Paraná to Minas Gerais has reduced the vulnerability of this crop to freezes. Yet soybean production that replaced coffee in Paraná brought with it major environmental changes and adverse societal consequences.

d) *Government responses have been effective in some cases, and ineffective in others.* The principal experience in terms of government responses to the consequences of climate variability involves droughts in the Northeast, where such responses have reduced human suffering during adverse climatic events but have not yet reduced the extreme vulnerability of the poor population. Some lessons indicate that government responses must be institutionalized and incorporated into the long-term development planning process. Government responses must be designed within the context of long range and stable government policies, must be accepted by society at large, especially by those who are supposed to benefit from these policies (specifically the vulnerable population), and must be determined in a democratic fashion. Once determined, they must be adequately funded and persistently pursued.

e) *The important issue of how to increase resilience to climate variability must be viewed in the context of the specific phenomenon.* In the worst case of prolonged drought in the Northeast, a region where drought is mainly a serious social problem, the only way to increase resiliency is through improving the living conditions of the poor. This requires economic development and changes in regional income distribution, which in turn requires increasing the productivity of local resources. Sustainable development is the proper answer: eradicate poverty, promote economic growth and improve the quality of the environment. In other adverse situations like the floods in Rio, emphasis must be put on land-use legislation and enforcement and on environmental education. The case of freezes may require adoption of new agricultural practices, introduction of new technological developments and crop substitution or relocation. In all cases, the central question of sustainable development must be addressed.

Can these lessons be useful if a climate change of a permanent nature is to occur? Certainly yes, because to many people climate change will materialize as a new pattern of climatic variability, with changes in the location, duration, frequency, and intensity of extreme meteorological events at the regional and local levels. If one learns how to cope with these phenomena today, this knowledge will be useful tomorrow, even if it serves only as a first approximation of possible future responses.

One very important lesson from dealing with past and present climate variations is that there is the need for stable policies. These policies must be considered as a part of a broader development strategy. In order to prepare for future climatic changes, it is necessary to pursue a new style of development, where the idea of economic growth must be constrained by the need to promote social equity (intra- and inter-generational). More specifically, the promotion of sustainable development strategies is the proper answer for Brazil today to prepare to cope with future climatic changes. This requires the strengthening of institutions that are involved in the countries development process and the adoption of long-term strategies that allow the necessary lead time for improvement of educational levels, land use patterns, environmental rehabilitation and cultural development.

One of the key requirements for this recommendation is the need for increased international cooperation. The adoption of development strategies that are environmentally-friendly depends on the access of Brazil, as well as of other industrializing and developing countries, to technologies and capital markets. It is clear that for the sake of saving the planet from "global" problems, developing nations should not pursue a development path based on existing and tested technologies that are environmentally unsound (the development path that the present industrialized countries have pursued). This fact manifests the requirement for a shared responsibility of all countries for the sustainable development of the developing countries.

Finally, it is necessary to expand and improve knowledge about climate variability and change and its impacts in the diverse regions of Brazil. Looking into the future, it is necessary to project present social, economic and environmental patterns to the horizon of one generation or more, so that the best opinion can be formed about the near future of our society. Together with these societal projections, alternative scenarios of climatic change can be constructed, based on a cautious use of general circulation models and other scientifically-based methodologies. It is quite possible that these projections will indicate that if nothing is done to change the current development path, Brazil and other countries like it will experience increasing difficulties in coping with the environmental and social problems of the future. For this reason, these long-term prospects may provide guidelines for political action now in search of a sustainable development strategy.