STAFF APPRAISAL REPORT

BRAZIL

NATIONAL IRRIGATION PROGRAM

NORTHEAST IRRIGATION I PROJECT

JANUARY 19, 1990

Agriculture Operations Division
Country Department I
Latin America and the Caribbean Region
CURRENCY EQUIVALENTS
(As of May 15, 1989)

Currency Unit = New Brazilian Cruzado (NCz$)
US$1.00 = NCz$ 1.112 (May 1989) 1/
NCz$1.00 = US$ 0.8952

WEIGHTS AND MEASURES

The metric system is used throughout the report.

FISCAL YEAR

Government of Brazil = January 1 to December 31
Project = January 1 to December 31

1/ As of December 11, 1989 (negotiations) the exchange rate was US$1.00 = NCz$ 7,776.
**GLOSSARY OF ACRONYMS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Name</th>
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<tbody>
<tr>
<td>BB</td>
<td>Banco de Brasil (Bank of Brazil)</td>
</tr>
<tr>
<td>CEPISA</td>
<td>Centrais Elétricas do Piauí (State Electric Company of Piauí)</td>
</tr>
<tr>
<td>CODEVASF</td>
<td>Companhia de Desenvolvimento do Vale do São Francisco (São Francisco Valley Development Company)</td>
</tr>
<tr>
<td>COELBA</td>
<td>Companhia de Eletricidade do Estado da Bahia (State Electric Company of Bahia)</td>
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<tr>
<td>COELCE</td>
<td>Companhia Energética do Ceará (State Electric Company of Ceará)</td>
</tr>
<tr>
<td>CHESF</td>
<td>Companhia Hidro-Eletrica do São Francisco (São Francisco Valley Hydroelectric Company)</td>
</tr>
<tr>
<td>DNOCS</td>
<td>Departamento Nacional de Obras Contra as Secas (National Department for Drought Related Works)</td>
</tr>
<tr>
<td>DNOS</td>
<td>Departamento Nacional de Obras e Saneamento (National Department of Sanitary Works)</td>
</tr>
<tr>
<td>MINAGRI</td>
<td>Ministério da Agricultura (Ministry of Agriculture)</td>
</tr>
<tr>
<td>POA</td>
<td>Plano Operativo Anual (Annual Operating Plan)</td>
</tr>
<tr>
<td>PROINE</td>
<td>Programa de Irrigação para o Nordeste (Irrigation Program for the Northeast)</td>
</tr>
<tr>
<td>PRONI</td>
<td>Programa Nacional de Irrigação (National Irrigation Program)</td>
</tr>
<tr>
<td>RIMA</td>
<td>Relatório de Impacto sobre o Meio Ambiente (Environmental Impact Statement)</td>
</tr>
<tr>
<td>SA</td>
<td>Special Account</td>
</tr>
<tr>
<td>SEPRONI</td>
<td>Secretaria Executiva do Programa Nacional de Irrigação (Executive Secretariat for the National Irrigation Program)</td>
</tr>
<tr>
<td>SUCAM</td>
<td>Superintendência de Campanha de Saúde Pública (Superintendency of Public Health Campaigns)</td>
</tr>
<tr>
<td>USBR</td>
<td>United States Bureau of Reclamation</td>
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This document has a restricted distribution and may be used by recipients only in the performance of their official duties. Its contents may not otherwise be disclosed without World Bank authorization.
The project is based on the findings of a Bank appraisal mission which visited Brazil from May 15, 1989 to June 16, 1989. The mission was comprised of Messrs. C. Emanuel (Mission Leader), Francesco Vita, Pari Awan (FAO/CP), and Michael Raczynski (Consultant).
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Map No. IBRD 21804
IBRD 21805
BRAZIL

NATIONAL IRRIGATION PROGRAM

NORTEZAST IRRIGATION PROJECT

I. LOAN AND PROJECT SUMMARY

**Borrower:** Federative Republic of Brazil.

**Executing Agencies:** Ministry of Agriculture (MINAGRI); Sao Francisco Valley Development Company (CODEVASF); National Department for Anti-Drought Works (DNOCS); and National Department for Sanitation (DNOS).

**Amount:** US$210.0 Million equivalent.

**Terms:** Repayable over 15 years, including 5 years of grace, at the Bank's standard variable rate.

**Beneficiaries:** The project would benefit about 3,380 small farmers to be settled on 6 to 8 ha plots, 590 medium-size farmers who would be allocated farms of 16 to 20 ha and about 270 large farmers who, through a bidding process, would obtain plots of 24 to 80 ha. In addition, the project would provide 2 to 4 ha plots for about 980 smaller holders currently living in the project area and access to waterpoints or equipment kits for about 160 small holders in areas adjacent to the project. Also, some additional 24,000 low-income rural families would benefit from the project through the creation of permanent and part-time employment.

**Project Objectives and Description:** The proposed project would be part of the National Irrigation Program. Its main objectives are: (i) to increase agricultural production in the drought-prone area of the Brazilian Northeast, through the development of irrigation of some 51,000 ha; and (ii) to strengthen institutional arrangements for irrigation development by promoting increased farmer involvement through the creation of private irrigation districts and by improving public agency performance.

The project would finance: (a) the construction of six public irrigation schemes in three Northeastern States; (b) the initial operation of private irrigation districts; and (c) the provision of technical assistance to the executing agencies. The irrigation schemes would be implemented by CODEVASF (Formoso H and Barreiras Norte, Bahia), DNOCS.
(Tabuleiros de Russas and Acarau, Ceará) and DNOS (Tabuleiros Litoraneos and Guadalupe, Piauí).
MINAGRI’s Executive Secretariat for the National Irrigation Program would provide overall coordination and supervision. At the beginning of the agricultural production stage, projects built by DNOS would be transferred to DNOCS. Irrigation districts would be organized in each irrigation scheme to provide support services to members and to operate and maintain the project works, with substantial private sector participation.

**Project Risks:**

The risks associated with the project are: (a) delays and shortfalls in counterpart funding; (b) institutional inefficiency; and (c) potential farmer reluctance to pay water charges for full recovery of capital and operation and maintenance costs. To minimize the risk of inadequate counterpart funds, during negotiations explicit agreements were provided by the Federal Government on funding procedures and budget amounts. To ensure efficient implementation, Project Management Units would be established in each of the Executing Agencies, reporting directly to the head of the agency; field units would also be established at each project site. The project would also include considerable technical assistance to develop the federal agencies' institutional capacity. The collection of water charges by local irrigation districts and improved enforcement of legal punitive measures to be set forth in the contracts to be signed with the farmers should lead to effective cost recovery.
<table>
<thead>
<tr>
<th></th>
<th>Local</th>
<th>Foreign</th>
<th>Total</th>
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<tbody>
<tr>
<td><strong>Estimated Project Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Construction of Six Irrigation Schemes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation Works</td>
<td>221.1</td>
<td>80.8</td>
<td>302.9</td>
</tr>
<tr>
<td>Electrical Networks</td>
<td>9.2</td>
<td>4.8</td>
<td>14.0</td>
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<tr>
<td>Road System</td>
<td>7.8</td>
<td>1.4</td>
<td>9.2</td>
</tr>
<tr>
<td>Administrative buildings</td>
<td>2.7</td>
<td>0.4</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td>241.8</td>
<td>87.4</td>
<td>329.2</td>
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<td><strong>Initial Operation of the Irrigation Districts</strong></td>
<td></td>
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<td>Management of the</td>
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<td>Irrigation Districts</td>
<td>2.1</td>
<td>0.1</td>
<td>2.2</td>
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<td>Agricultural Services</td>
<td>2.0</td>
<td>0.1</td>
<td>2.1</td>
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<td>Operation and Maintenance</td>
<td>16.9</td>
<td>4.0</td>
<td>20.9</td>
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<td>Environmental Protection</td>
<td>1.3</td>
<td>0.1</td>
<td>1.4</td>
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<td><strong>Sub-Total</strong></td>
<td>22.3</td>
<td>4.3</td>
<td>26.6</td>
</tr>
<tr>
<td><strong>Technical Assistance and Consultant Services</strong></td>
<td></td>
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<td>Technical Assistance</td>
<td>3.0</td>
<td>8.0</td>
<td>11.0</td>
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<td>Monitoring System</td>
<td>3.0</td>
<td>0.3</td>
<td>3.3</td>
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<td>Consultant Services</td>
<td>18.2</td>
<td>4.5</td>
<td>22.7</td>
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<td><strong>Sub-Total</strong></td>
<td>24.2</td>
<td>12.8</td>
<td>37.0</td>
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<td><strong>TOTAL BASELINE COSTS</strong></td>
<td>288.3</td>
<td>104.5</td>
<td>392.8</td>
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<td>Physical Contingencies</td>
<td>22.2</td>
<td>8.0</td>
<td>30.2</td>
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<td>Price Contingencies</td>
<td>31.0</td>
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<td><strong>TOTAL PROJECT COSTS</strong></td>
<td>341.5</td>
<td>123.5</td>
<td>465.0</td>
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<td><strong>FINANCING PLAN</strong></td>
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<td>Government</td>
<td>205.0</td>
<td>-</td>
<td>205.0</td>
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<tr>
<td>IBRD</td>
<td>86.5</td>
<td>123.5</td>
<td>210.0</td>
</tr>
<tr>
<td>Farmers</td>
<td>50.0</td>
<td>-</td>
<td>50.0</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>341.5</td>
<td>123.5</td>
<td>465.0</td>
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**Estimated Disbursements**

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<tr>
<td>Annual</td>
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<td>7.8</td>
<td>59.0</td>
<td>62.2</td>
<td>54.8</td>
<td>22.0</td>
<td>4.2</td>
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<td>Cumulative</td>
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<td>7.8</td>
<td>66.8</td>
<td>129.0</td>
<td>183.8</td>
<td>205.8</td>
<td>210.0</td>
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**Rate of Return:** 16%

(a) Including about US$44.0 M equivalent of local taxes and duties.
(b) Including an initial deposit of US$5.75 M into the Special Accounts.
II. THE AGRICULTURAL SECTOR

Agriculture in the National Economy

2.01 Throughout the postwar period, until the 1980s, the economy grew at a high average annual rate of 7.1%. The agricultural sector also performed well, achieving an average annual growth rate of about 4.4% over the same period. However, the outputs of both the industrial and service sectors increased at much faster rates - 8.5% and 7.0%, respectively. As a result, agriculture's share in GDP declined from about 25% in 1950 to 10% in 1980.

2.02 Agricultural production growth prior to 1980 was led by the growth of non-traditional exports (mainly soybeans and citrus). Production increases came almost entirely from new area expansion as opposed to increases in yields. Production was particularly dynamic in the expanding frontier states of the Center-West (Goiás and Mato Grosso do Sul) and parts of Minas Gerais.

2.03 In the early 1980s, the economy slowed down, reflecting declines in industrial production and stagnation in agriculture. In addition, the expansion of the agricultural frontier came to a virtual halt, with the exception of areas in the North. In the last couple of years, agricultural growth has resumed. However, the sources of growth appear to be changing. With the recent introduction of new varieties, made possible by technological advances in agricultural research, yields on traditional export crops (cotton, tobacco and coffee) and many food crops (rice, maize and wheat) have increased significantly. During the 1980s, very little change occurred in the overall structure of output. By 1987, agriculture still accounted for about 10% of GDP. Its share in the labor force and total exports was 25% and 43%, respectively.

Agricultural Development Policy

2.04 Government policies have had a major impact on the performance of the agricultural sector. Probably the most important action in this regard was Brazil's decision in the postwar era to embark on an import-substitution, industrialization strategy. This strategy has been pursued through a variety of measures, including an overvalued currency, restrictive trade policies, and from time to time, outright bans and quotas on agricultural exports. The effect has been to implicitly tax agriculture. Partially to compensate for this, subsidized rural credit was introduced, but this only created further distortions and benefitted mainly large producers. Recently, the Government has moved to change some of these policies. The Bank has supported some of these reforms under the Credit and Marketing Reform Project (Loan 2727-BR). With respect to rural credit, the Government is now moving in the direction of reducing the availability of official (subsidized) credit and relying on private finance at market interest rates. A recent Bank-supported agricultural credit operation, the Agricultural Credit Project (Loan 2971-BR), is aimed at assisting the Government to achieve this objective.

2.05 While the Government policy agenda during the 1980s has been dominated by macroeconomic stabilization concerns, farmers, faced with the
problem of increasing production costs and falling commodity prices, have
grown to seek more cost-effective technologies and to intensify the use of
existing farm land and rural infrastructure. This is already evident in
the country's major agricultural areas in the South and Southeast. There
is growing interest in irrigation, soil conservation, environmental
protection, livestock disease control, more efficient marketing and storage
and more widespread application of the results of agricultural research.
Recent evidence indicates that the supply of unclaimed agricultural land
with economic potential is rapidly diminishing. This fact, combined with
the Government's recent initiatives to withdraw part of the various fiscal
incentives that have, to an important extent, fueled this expansion,
suggest that the growth of the land frontier may be coming to a close.
Agricultural growth in the future is expected to come increasingly from
more land-intensive production methods.

The Rural Northeast

2.06 The Northeast of Brazil comprises the States of Maranhao, Piauí,
Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia,
the northern part of Minas Gerais and the island of Fernando de Noronha.
The region covers a total area of over 1.5 million km² (18% of the
country's total area).

2.07 The Northeast has been the nation's foremost problem region since
the late 1800s because of periodic droughts, uncertain rainfall, skewed
land distribution, and limited employment opportunities. These problems
have resulted in high levels of poverty and underemployment. From 1970 to
1983, 3.3 million people migrated from the region, partially in response to
a five-year drought (1979-1983). In 1980, the Northeast had a total
population of 35 million (about 29% of the country's total), growing at
2.2% per annum with a population density of 22.5 inhabitants per km². In
1985, 45% of the population lived in rural areas and more than 39% of the
work force was engaged in agriculture. Land ownership is highly
concentrated: Farms under 10 ha (70% of all farms) occupy less than 6% of
the farm area; farms over 500 ha (1% of all farms) occupy 47% of the farm
area. Rural incomes are low. In 1985, about half of the Northeast rural
population earned one quarter or less of the official minimum wage (about
US$600 annually).

2.08 The Northeast contributes about one-fifth of the total value of
Brazilian agriculture; many regionally produced commodities (cotton,
sisal, cassava and sugar) represent significant shares of national
production. The Zona da Mata, a narrow, fertile coastal strip, contains
one-third of the regional population and a major proportion of industry and
plantation agriculture. The Agreste, a transitional zone contiguous with
semi-arid areas, is dominated by mixed farming, as well as the raising of
cattle. The sparsely populated, semi-arid Sertao is the largest of the
sub-regions and the most vulnerable to periodic droughts. Irrigated
agriculture represents only a small proportion of land under cultivation.
Irrigated lands are mainly located along the Sao Francisco River and
downstream of storage dams.
Irrigation Development in Brazil and the Northeast

2.09 With the exception of paddy rice and limited riverine strips, irrigated crop production is a fairly recent development in Brazil. In 1970, the total irrigated area in the country was only 0.3 million ha. Today it is estimated at over 2.2 million ha, of which about 440,000 ha are in the Northeast region. Most of Brazilian irrigation development was undertaken by the private sector, but in the Northeast about 92,000 ha have been developed by three federal agencies, the Sao Francisco Valley Development Company (CODEVASF), the National Department for Anti-Drought Works (DNOCs), and to a lesser extent, the National Department for Sanitation (DNOS). CODEVASF, established in 1974, is responsible for the implementation of major public irrigation systems in the Sao Francisco River Valley. It currently operates 18 irrigation projects with some 66,000 ha developed and 15,000 ha in various stages of construction. As a public sector enterprise, modelled on the U.S. Tennessee Valley Authority, it has greater autonomy than either DNOCs and DNOS (both of which are "autarchies" with limited autonomy). CODEVASF has around 2,200 permanent staff, many of them highly qualified agricultural and irrigation technicians. DNOCs is responsible for the construction of drought and flood protection works and irrigation infrastructure in other river valleys in the Northeast. It operates 23 irrigation schemes in one of the most difficult environments in the country (the semi-arid sertão), covering some 21,000 ha fully developed and 8,500 ha in different stages of implementation. In the past, its performance in irrigation development has been poor due to overly centralized decision making at the project level, excessive and unsuitable staff, administrative interference in its operations, and overly paternalistic policies. To improve its performance, DNOCs is currently undergoing administrative and organizational reform and developing more participatory approaches, including farmer involvement in project management. DNOS is responsible for the construction and operation of large-scale public works to protect areas from periodic floods, mostly in the Southeast and South. In the past, DNOS also built and operated public irrigation infrastructure in the South. In the Northeast, DNOS is currently building five irrigation schemes, covering a net area of about 7,900 ha. While its construction capacity is satisfactory, only a few of DNOS's 2,300 permanent staff are trained agricultural and irrigation technicians. In general, past public irrigation development has been slow, although some projects, including the Bank-financed Sao Francisco I (Loan 1153-BR) and Sao Francisco II (Loan 1729-BR) projects, have been relatively successful (para.2.14).

2.10 In February 1986, the Government consolidated most federal irrigation functions in a new National Irrigation Program office within the Presidency, and placed it under the direction of an Extraordinary Minister of Irrigation Affairs. The Minister was charged with drafting the policy and organizational framework for accelerating private sector investment, rationalizing and expanding public sector agency activities, particularly in the Northeast, and securing support for an integrated national irrigation development effort. The National Irrigation Program was created with two coordinating bodies--PROINE (Northeast Irrigation Program) and PRONI (National Irrigation Program). These two bodies were responsible for the coordination and promotion of irrigation programs in the Northeast and in the rest of the country, respectively. Plans were to increase the total irrigated area in Brazil by 3.0 million ha, or 120%, over five years
(1986-90) -- 400,000 ha of public and 600,000 ha of private irrigation in the Northeast, and 2.0 million ha of private irrigation in the rest of the country. These targets have been scaled back considerably over the past two years because of PROINI's and PROINE's initial planning and coordination difficulties, a growing understanding of the technical and institutional constraints, cutbacks in the availability of federal and state funds, and the dampened economic environment within the country. Recently, PROINE was merged into PROINI, and under a January 1989 administrative reform, the Special Ministry of Irrigation was abolished and PROINI was transferred to the Ministry of Agriculture. PROINI continues to operate with the same structure and staff within a recently created Executive Secretariat for the National Irrigation Program (SEPRONI).

2.11 After a series of issues-oriented discussions within Brazil and the Bank in 1988, the Government decided to launch an irrigation subsector review. The review was carried out in two stages: a Government study followed by a joint Government/World Bank discussion of the subsector in the first half of 1989. Among other topics, the subsector review identified several major reasons for the poor past performance of public interventions in the irrigation subsector in the Northeast region (para. 2.09): (a) non-economically viable agricultural development plans based on inexperienced, small farmers growing subsistence crops; (b) inadequate selection of investments in the subsector; (c) serious institutional constraints; and (d) lack of timely provision of funds for project implementation. With regard to future public irrigation projects in the Northeast, the Subsector Review recommended that: (a) future schemes should be economically viable and production-oriented; (b) operation and maintenance costs and public investments in off-farm irrigation infrastructure should be recovered from beneficiaries through water charges; (c) private autonomous irrigation associations or districts should be organized to handle overall management; (d) most future irrigation development should be demand-driven, with maximum participation of the private sector and the beneficiaries; and (e) CODEVASF and DNOCS should limit their development activities to the Sao Francisco basin and to the areas outside of the basin, respectively; DNOS should finish works already started and progressively limit its role to the supervision of projects which it has constructed.

Past Bank Lending in the Agricultural Sector

2.12 As of December 31, 1989, the Bank had made 55 loans, totalling US$4,607.8 million (net of cancellations), for agricultural and rural development in Brazil. These loans include: one agricultural credit and export loan for US$303 million; one agricultural credit loan for US$300 million; one credit and marketing reform loan for US$500 million; two supplemental loans for US$30.5 million under the 1983 Special Action Program; four loans for US$785.8 million for agroindustries; three for US$111.5 million, for livestock, including an animal disease control project of US$51 million; one for US$18.2 million for grain storage; three for US$147.0 million for agricultural research; two for US$255 million for agricultural extension; one for US$100 million for land tenure improvement; one for US$48.5 million for forestry development; one for US$195 million for the irrigation subsector; and 34, totalling US$1,813.3 million for various settlement, irrigation, land management and rural development
projects in the Northeast, in Minas Gerais (the Southeast), Paraná (the South), and in the North and Northwest.

2.13 In support of PRONI, the Bank has granted loans for the Northeast Technical Assistance and Irrigation Engineering Project (Loan 2680-BR) for US$48 million in March 1986; the Upper and Middle Sao Francisco Irrigation Project (Loan 2719-BR) for US$57 million in May 1986; the Itaparica Resettlement and Irrigation Project (Loan 2883-BR) for US$132 million approved in November 1987; the Irrigation Subsector Project (Loan 2950-BR approved in June 1988); and the Jaiba Irrigation Project (Loan 3018-BR) for US$71.0 million approved in December 1988. The engineering project provides technical and financial support for regional irrigation planning and detailed study and design of possible future public irrigation projects. The Upper and Middle Sao Francisco Irrigation Project is implemented by CODEVASF and provides for the rehabilitation of 17,800 ha or irrigated land and the development of some 11,000 ha of new lands. The Itaparica project provides for the development of some 17,700 ha of irrigation for some 5,300 families resettled as a result of the construction of the Itaparica Hydroelectric Project. The Jaiba Project provides for the development of irrigated agriculture on some 23,600 ha in the northeast region of the State of Minas Gerais. The Irrigation Subsector Project provides technical and financial support for private irrigation development in the highlands and flood plains of the Center West, Southeast, and Southern regions of the country. Although initial implementation in some cases has been slow, the projects are progressing satisfactorily.

2.14 Prior to these recent irrigation efforts, the Bank was involved in two other CODEVASF irrigation projects. The Lower Sao Francisco I Polder Project (Loan 1153-BR for US$23 million, approved in August 1975) and the Lower Sao Francisco II Irrigation Project (Loan 1729-BR for US$29.0 approved in June 1979, and Supplemental Loan 1729-1-BR for US$7.7 approved in December 1983) were a follow-up to the Paulo Alfonso IV/Sobradinho Hydropower Project. The projects were needed to compensate for changes in the flow regime of the river caused by the operation of the hydropower project, which affected the fertile floodlands (várzeas) downstream of the dam. The projects financed the construction of protective dikes and the establishment of irrigation in six large flood plains (12,000 ha), improving the livelihood of about 11,000 families. During the first years, the projects suffered serious delays mainly due to organizational difficulties within CODEVASF, and inadequate implementation of social and land tenure improvement activities. However, the Project Performance Audit Report for the Lower Sao Francisco I Polder Project and the Project Completion Report for the Sao Francisco II Irrigation Project showed that despite these implementation delays and lower than expected economic rates of return, net income of beneficiaries increased beyond original estimates and many small farmers moved from subsistence agriculture to commercial farming. In addition, yields have been improving considerably in recent years, at times reaching values higher than appraisal estimates.
III. THE PROJECT

A. General

Rationale for Bank Involvement

3.01 The Bank's assistance strategy for Brazil is to support policies and investments that will encourage economic growth and social development in a context of macroeconomic stability, with emphasis on efficient resource allocation and administration in the public sector, and appropriate targeting and delivery of support systems to the poor. Irrigation development, because of its ability to intensity use of agricultural lands and to increase production and productivity, is potentially one of the most cost-effective strategies for achieving sector efficiency and growth. The Bank, through its support for selected interventions, including the Northeast Irrigation Engineering Project (Loan 2680-BR), the Upper and Middle Sao Francisco Irrigation Project (Loan 1729-BR), the Irrigation Subsector Project (Loan 2950-BR) and the Jaiba Irrigation Project (Loan 3013-BR) as well as through its sector work, including the joint Irrigation Subsector Review (para. 2.11), is assisting the Government in formulating and implementing new policies and operational strategies for a more efficient and rapid subsector development. Through its support for the proposed project, the Bank would assist the Government in implementing reforms with respect to public irrigation in the Northeast on a relatively broad scale. Finally, since the proposed project would generate increased economic activity and employment opportunities in rural areas of the country's poorest region, the Bank would also be assisting Government efforts to alleviate poverty in the Northeast.

Project Origin and Objectives

3.02 The main objective of the project is to increase agricultural production in the drought-prone area of the Brazilian Northeast through the development of irrigation on some 51,000 ha. In addition to this production objective, a fundamental objective of the project is to further subsector development by addressing a range of institutional issues within a group of agencies who will be engaged in future irrigation development. As a part of this objective, improved project management and operation and maintenance arrangements would be implemented through the creation of private irrigation districts in each of the irrigation schemes under the project. These arrangements would be put into place on a large scale for the first time outside of the Sao Francisco River Basin.

3.03 Following the creation of PROINE, the Bank helped finance the Northeast Irrigation Engineering Project (para. 2.13) which includes the preparation of: (a) a number of subsector studies focused on major issues such as training, cost recovery and operation and maintenance; and (b) prefeasibility, feasibility, and detailed designs for some of the most potentially promising public irrigation projects in the Northeast. The proposed project would finance the subsequent stages of construction of six medium-size irrigation schemes prepared by the Government with the assistance of private consulting firms and the U.S. Bureau of Reclamation (USBR) (para. 3.25). The present project forms part of the National Irrigation Program (1990-1995) outlined in the sector review and follows its recommendations.
The Project Area

3.04 The irrigation schemes are located in the States of Bahia (Formoso and Barreiras Norte), Ceará (Acará and Tabuleiros de Russas), and Piauí (Guadalupe and Tabuleiros Litorâneos). All of them lie within the drought polygon in the Northeast, which is characterized by monthly temperatures of 21°C to 27°C and annual rainfall concentrated in a five-month period and averaging from 250 mm to 1,200 mm. Undependable rainfall is the major constraint for rainfed agricultural production in the project area. Since 1900 there have been 12 severe drought periods, the most recent of which occurred during the period 1979-1983. In years of “normal” rainfall the erratic distribution of rainfall during the growing season also adversely affects agricultural production. Cotton and subsistence crops are the hardest hit by these severe climatic conditions. Extensive analysis shows that for beans (average growing period of 80 days) the probability of complete production failure in any given year varies from 38-95%, while for maize (average growing period of 120 days), it varies from 44-98%, depending on location.

3.05 The drought-polygon area has a limited potential for irrigation development. Some 80% of the region has shallow soils of crystalline origin with poor fertility and low water storage capacity, and overlying rocks with limited aquifers, sometimes containing saline ground water. Also, most of the region’s rivers have intermittent, torrential flows and remain dry during part of the year, or even throughout the year during droughts. To conserve rainfall and reduce flood risks, the Government has built some 292 medium and large reservoirs over the last 80 years with total storage capacity of more than 17 billion m³. At present, there are only a limited number of locations, including those selected under the project, where sufficient water can be economically brought to land of adequate fertility to enhance agricultural production.

Project Beneficiaries

3.06 The project would have four types of direct beneficiaries in order to maximize returns from relatively high investment and operational costs and to ensure improved technology transfer to small farmers. The four types include: (a) about 3,380 qualified small farmers (6 to 8 ha plots) selected according to agreed criteria that ensure their capability to operate their holdings on a commercial basis without government subsidies; (b) about 590 medium size holders (16 to 24 ha plots), preferably farmers or agricultural technicians with proven experience in commercial farming; (c) about 270 large irrigators, who through a bidding process would acquire farms ranging from 24 to 100 ha; and (d) about 980 small farm families currently living in the areas to be developed. The last type of beneficiary would be allotted 2 to 4 ha irrigated plots close to their present homes within the project area (para. 3.10). In addition, the project would provide simple irrigation equipment for about 160 small holders who live in areas directly adjacent to the project (Annex V). The project would also benefit some 24,000 low income families through the generation of permanent and part-time employment.
Environmental Aspects

3.07 The Environmental Impact Statements (RIHAs), prepared for each individual scheme by consultants acceptable to the Bank, conclude that the project would have only a limited effect on the environment, provided certain environmental protection measures are implemented. These refer basically to: (a) preparation of rational land clearing programs; (b) monitoring of water tables and water quality; (c) monitoring of endemic diseases and their vectors; and (d) environmental education of the beneficiary farmers. The preparation of rational land clearing programs would include an inventory of vegetal species, delimitation of land clearing areas, establishment of environmental reserves and escape corridors for the fauna, selection of appropriate land clearing methods and utilization of forestry resources such as timber, firewood or the production of charcoal.

3.08 The six irrigation schemes would utilize only the amounts of water already available during drought periods and no new storage facilities would be required. Risks of land degradation due to waterlogging and salinity would be minimum since the irrigation schemes have been planned and designed using modern irrigation technology. Except for about 550 ha in Formoso H Irrigation Scheme, all project lands would be irrigated by sprinkler and localized irrigation methods, which use water most efficiently. A proper drainage network, well adapted to the natural drainage system, has also been designed, as well as a system to monitor the water table variations and water quality during the life of the project. Also, the selected irrigation methods would allow for the adoption of water and environmental quality control practices, including better fertilizer application.

3.09 The project would also address issues related to health and environmental education. The selection of potential farmers would include a medical check-up for the candidates and their families, including detection of endemic diseases. Furthermore, the project would support SUCAM (Superintendency for Public Health Campaigns) campaigns against water borne diseases and vector monitoring programs. Except for the surface irrigated area in Formoso and the Acarau and Russas schemes, the remaining project area (68% of total) would be supplied through pressurized pipes which would reduce the number of habitats suitable for water borne disease organisms and their vectors. Supported by the project, SUCAM would carry out a campaign against water borne diseases in the project areas. Finally, the agricultural extension service would carry out an environmental education program for project beneficiaries (para. 3.21).

Resettlement of the Affected Population

3.10 The construction of the irrigation works would affect about 980 small rural families, including tenants, sharecroppers and rural workers. These families are currently living within the borders of the Acarau (about 140 families), Tabuleiros de Russas (about 430 families), Tabuleiros Litoraneos (about 155 families), Guadalupe (about 45 families), and the Barreiras (about 210 families) irrigation schemes. CODEVASF, DNOS and DNOS have prepared resettlement plans approved by the Bank and the affected populations. The resettlement program includes the provision of irrigated family plots (in accordance with the regulations of the National Irrigation
Law) close to their present homes within the irrigated perimeters. The 980 families (about 80% of the affected population) would be resettled on 2 to 4 ha plots. An additional 190 families, who are more advanced technologically, are likely to qualify to receive 8 ha plots within the irrigated areas of the project. Another 45 farmers, most of whom are currently retired, would be resettled in nearby urban areas. Resettlement plans involve a series of routine preparatory steps for each community including: (a) a communication campaign; (b) an inventory of livestock to be transferred; (c) ratification of resettlement agreements by each family; and (d) arrangements for actual transfer of families and their belongings. During negotiations, CODEVASF and the Federal Government provided assurances that the resettlement plans would be implemented by CODEVASF, DNOCS and DNOS in accordance with the terms defined in the resettlement plan approved by the Bank.

B. Project Description

3.11 The project would consist of: (a) construction of six new irrigation schemes covering a net area of about 51,000 ha; (b) assistance for the initial operation of six private irrigation districts which would be responsible for providing farmers with agriculture extension, training and marketing services, operation and maintenance of irrigation and drainage networks, environmental protection measures and project administration; and (c) provision of technical assistance to PRONI and DNOCS, and consultant services for construction supervision of the irrigation schemes. Under (a), the project would finance the construction of off-farm irrigation and drainage works, electrical and road networks, and on-farm irrigation equipment for small holders (medium and large farmers would develop their own on-farm systems). Under (b), the project would finance, on a declining basis, following the completion of off-farm irrigation works, up to three years of the operating costs of each irrigation scheme, including the overall management of the irrigation district, the agricultural extension and marketing services for the farmers, as well as the operation and maintenance of the irrigation and drainage works and services and equipment for environmental protection measures. Under (c), the project would finance international technical assistance to PRONI and DNOCS, operating costs for the development of a monitoring information system, and the costs of the consultant services required for construction supervision of the irrigation schemes, and preparation of detailed engineering designs for the Pontal irrigation scheme.

Construction of Six New Irrigation Schemes (84% of baseline costs)

3.12 Formoso H Irrigation Scheme (4,875 ha). The subproject would be located in the State of Bahia and would be implemented by CODEVASF. Water would be diverted and pumped (6.05 m³/sec) from the Corrente River into two lined main canals of different elevations (18 m and 28.5 m, respectively). The lower one would deliver water to about 545 ha of heavy soils for gravity irrigation and 315 ha of light to medium textured soils for sprinkler and/or localized irrigation. The upper canal would directly supply water to 585 ha for sprinkler and localized irrigation and to a second pumping station (Q = 3.7 m³/sec) to lift water 14 m into a third main canal. This canal would supply 14 pressurized pumps, each serving one hydraulic sector of about 250 ha. The entire system would be fully
automated. Energy would be supplied by the Electric Company of Bahia, COELBA, from the existing substation at the neighboring Formoso "A" project, financed by the Bank under Loan 2719-BR. The area would be settled in 6 to 50 ha farms, and farmers would receive pressurized and metered water.

3.13 Barreiras Irrigation Scheme (8,725 ha). The subproject would be located in the State of Bahia and implemented by CODEVASF. The scheme would irrigate three separate sub-areas: Barreiras Norte (3,330 ha), Riacho Grande (1,975 ha) and Nupeba (3,420 ha). The areas would be settled in 2 to 4 ha, 7.5 ha, 15 ha, 22.5 ha and 30 to 80 ha farms. Medium-textured soils are dominant in the subproject area. Water for the three sub-areas would be pumped from the Rio Grande River. Six pumping stations would lift water at 6.25 m³/sec between 72 m and 91 m during peak water demand periods. Four booster stations would lift the water an additional 15 to 21 m to allow irrigation of the higher lying areas. Water would be discharged into six regulating reservoirs for subsequent delivery to a buried pipeline network leading to the individual holdings. Farmers would receive pressurized and metered water. The project would finance the construction of a 35 transmission line (34.5 KV) from Angical to São José do Rio Grande, for provision of energy to the main pumping stations.

3.14 Acaraú Irrigation Scheme (8,210 ha). The subproject would be located in the State of Ceará and implemented by DNOCs. The project would pump water from the Acaraú River to irrigate 2 to 4 ha, 8 ha, 16 ha and 80 ha production units using sprinkler and drip irrigation methods. Project soils are deep but light textured (sandy loams or sandy clay loams). Headworks would comprise a diversion dam across the Acaraú River and a main pumping station. Civil works would be built to serve future expansion, (4,500 ha) but equipment would be limited to meet the demands of the proposed first phase development (Q = 10.5 m³/sec, H = 45 m). Two pressure lines would discharge the water into a lined main conveyance canal from where it would be distributed by a 50 km lined canal distribution network. Each farm would have its own individually operated pressurization pump. Energy for the project would be supplied from a 75 km transmission line (69 KV), Sobral-Acaraú, to be built by CHESF in 1990.

3.15 Tabuleiros de Russas Irrigation Scheme (10,500 ha). The subproject would be located in the State of Ceará and implemented by DNOCs. Water would be pumped from the Banabuiú River to irrigate small holdings (2 to 4 ha and 8 ha) medium-size farms (16 to 20 ha) and large farms (above 24 ha). Dominant soils are deep sandy loams. Off-farm irrigation works would include: (a) main pumping station (Q=13.3 m³/sec; H=31m) on the Banabuiú River; (b) 800m pressure line; (c) 17 km main conveyance canal (Q=30m³/sec); and (d) canal and pipe distribution network. The main canal has been sized to meet the needs of the proposed project and future expansions (15,000 ha). The distribution network would comprise 13.4 km of main canal (Q=13.3 m³/sec), a secondary pumping station (Q=8m³/sec; H=8m) and a 72 km canal and 68 km low pressure pipe network. Each farmer would have his own pressurization pump. The project would finance the construction of a 10 km transmission line (13.8 KV) and two electrical substations (5 MVA in COELCE and 10 MVA in Morada Nova). Additionally, another 17 km of 13.8 kv lines, financed by the project, would supply energy to individual pumping stations.
3.16 **Guadalupe Irrigation Scheme (11,870 ha).** The subproject would be located in the State of Piauí and built by DNOS, but coordination and overall management responsibility would be transferred at the beginning of the production phase to DNOCS (para. 3.30). Project soils are mainly light to medium textured red-yellow podzols. The area would be settled in 2 to 4 ha, 8 ha, 16 ha and 32 ha plots. At full development the irrigated area of the entire Guadalupe scheme would be about 14,870 ha, distributed in two different areas denominated Block 1 (7,100 ha), and Block 3 (7,770 ha). By the end of 1990, DNOS will complete using its own resources the construction of about 3,000 ha under Block 1. The project would finance the construction of works required to complete Block 1 (4,100 ha), and the full development of Block 3. Water would be pumped from the Boa Esperança Reservoir by two separate pumping stations. Block 1 would benefit from headworks under construction by DNOS. The project would only provide pumping equipment for the main pumping station at the Boa Esperança Reservoir to meet the needs of 4,000 ha (Q = 4.8 m³/sec, H = 34m) and a 1,100 m pressure line. The project would also include a second pumping station (Q = 4.2 m³/sec, H = 42 m) to pump water from the first phase main canal into a second level distribution canal network, to feed pressurization pumps (each serving between 540 and 1,200 ha) and a pressurized pipe network. Pressurized and metered water would be delivered to individual lots. Block 3 would have its own pumping station at the Boa Esperança Reservoir (Q = 10.26 m³/sec, H = 85 m). Three 3,300 m long pressure pipes would discharge water into a 19 km lined canal system. Sixteen pressurization pumps along the latter (each serving between 340 and 1,360 ha) would pressurize the pipe distribution network and deliver pressurized and metered water at the farm gate of each lot. Energy for the project would be provided by the Boa Esperança hydropower plant via a 12 km transmission line (34.5 KV), to be financed by the project, to the project's primary substation.

3.17 **Tabuleiros Litoraneos Irrigation Scheme (7,510 ha).** The subproject would be located in the State of Piauí, built by DNOS and transferred to DNOCS at the beginning of the agricultural production phase. The scheme would pump water from the Parnaiba River for the irrigation of about 8,300 ha, including about 7,510 ha under the proposed project. Most of the project soils have a texture ranging from sands to loamy sands. Headworks comprise an inlet canal and a main pumping station (Q = 13.1 m³/sec, H = 50 m). Two 1,560 m long pressure lines would discharge water into a regulating reservoir that would feed into a main conveyance canal. Most of those works have already been constructed by DNOS so the project would only provide the equipment and civil works to complete the pumping units and a 1,560 m long pressure line. The main conveyance canal would deliver 9.5 m³/sec to the proposed project distribution network. The latter would comprise 37.5 km of lined canals, 16 pressurization pumps (one for about 450 ha) and a pipe distribution network. Farms would receive pressurized and metered water at the farm gate. Small farms (plots of 8 ha) would use sprinkler irrigation; medium and large farms (plots of 16 ha and 32 ha, respectively) would use sprinkler and localized irrigation methods. Energy would be supplied by the Electric Company of Piauí, CEPISA, through a 150 km transmission line (69 KV) from Piripiri to Parnaiba, to be built by CHESF in agreement with the Minister of Energy and Mines, in 1990.
Initial Operation of the Private Irrigation Districts (7% of baseline costs)

3.18 Management of the Irrigation Districts. The irrigation districts would be responsible for the overall management of the irrigation schemes. They would also be responsible for the provision of operation and maintenance, agriculture extension and marketing services (charging its costs directly to the beneficiaries - Annex V) and the implementation of the environmental protection measures. The irrigation districts would be private associations under Brazilian law, and their members would be the project beneficiaries (para. 3.32 to 3.36). The project would finance the construction of administration facilities (offices, garages and workshops), and on the declining basis (para. 3.11) the costs of personnel required for the planning, budgeting, and coordination activities. At negotiations, CODEVASF and the Federal Government provided assurances that CODEVASF and DNOCS, in each of their respective irrigation schemes, would complete beneficiary selection by December 31, 1991, or by a later date to be agreed to by the Bank, and immediately thereafter, organize an irrigation district in each scheme, and maintain the district with an organization - including a General Manager and competent staff in adequate numbers - structure and functions, all acceptable to the Bank.

3.19 Agricultural Extension and Marketing Services. The objective of the agricultural extension and technical assistance to farmers would be to familiarize project small farmers with the most appropriate technological packages available for the irrigation of crops to be grown under the project (including relevant agricultural and water management practices). The irrigation districts, through the contracting of private firms, would advise small farmers on: (a) irrigation and water management practices; (b) appropriate use of fertilizers and control of pH levels through liming; (c) land preparation, seeding and planting; (d) effective weed control and plant/protection measures and efficient use of agrochemicals; (e) improved harvesting and storage methods; (f) economics of crop production and farm management for maximum profitability; and (g) alternative methods for marketing of produce and provision of inputs. The irrigation districts would also provide advisory services to the other project beneficiaries, i.e., agricultural technicians and large farmers, on an ad hoc basis. The project would finance extension services for small farmers for two years following settlement. The districts would also assist their members to market or export their products through monitoring of marketing conditions, looking for outlets, negotiating contracts, grouping merchandise and arranging for pickup, transportation and delivery. CODEVASF and the Federal Government provided assurances during negotiations that CODEVASF and DNOCS would cause each irrigation district to contract no later than three months after its establishment (para. 3.18) unless otherwise agreed to by the Bank, agricultural extension and marketing services to a specialized entity with qualifications and experience satisfactory to the Bank. The costs of such services would be financed by the project on a declining basis.

3.20 Operation and Maintenance. Project design includes advanced technologies to achieve maximum flexibility in water distribution required for optimal production of high value diversified crops. Water would be delivered on demand to each farm. Part of the districts' work would include measuring water consumption at the farm level and within the irrigation scheme, and operating and maintaining canals and related hydraulic
structures. The main pumping stations and the main canals and pressure lines would continue to be operated and maintained by the Executing Agencies. CODEVASF and the Federal Government provided assurances during negotiations that CODEVASF and DNOCS would cause each irrigation district to sub-contract, no later than three months after its establishment (para. 3.18) unless otherwise agreed to by the Bank, the provision of operation and maintenance services for irrigation works to a specialized entity with experience and qualifications satisfactory to the Bank. The related costs would be financed by the project on a declining basis during the first three years of project implementation.

3.21 **Environmental Protection Measures.** The project would provide for the installation of piezometers and observation wells for the monitoring of the water table and water quality during the life of the project (para. 3.08). Also the project would support SUCAM campaigns against water borne diseases and vector monitoring programs (para 3.09), and finance equipment and materials for the agricultural extension services to carry out an environmental education program for project beneficiaries (para 3.09). During negotiations, CODEVASF and the Federal Government provided assurances that CODEVASF and DNOCS would sign satisfactory agreements with SUCAM, no later than December 31, 1991, to carry out campaigns against water-borne diseases.

### Technical Assistance and Consultant Services (9% of baseline costs)

3.22 The technical assistance component, to be financed by the project (para. 3.12), has been designed to complement the technical assistance program financed out of the proceeds of the Northeast Irrigation Engineering Project (Loan 2680-BR). Its objectives are the following: (a) to prepare and assist SEI to take over many of the activities defined in the Irrigation Subsector Review (para. 2.11), so that when full-time technical assistance ends, SEI personnel will be qualified to implement the National Irrigation Program; (b) to develop and implement a management information system to monitor activities during the planning, construction and operating stages of the project (para. 3.38); and (c) to develop DNOCS' capability to oversee the agricultural development phase of the subprojects. The project would also finance the consultant services required for the preparation of construction plans and the supervision of construction of the irrigation schemes, and the preparation of engineering designs and other detailed studies for the Pontal Irrigation Scheme. SEPRONI has already prepared a preliminary design of the technical assistance program and a draft of a second-stage USBR Technical Assistance Project document. A condition of loan effectiveness would be that SEPRONI signs an agreement satisfactory to the Bank for the provision of technical assistance to the National Irrigation Program, and prepares a proposal acceptable to the Bank for the provision of technical assistance to DNOCS. The Federal Government also provided assurances during negotiations that the DNOCS technical assistance agreement would be entered into no later than May 30, 1990.

### Complementary Activities to the Project

3.23 **Agricultural Credit.** Beneficiaries would need medium-term investment and seasonal credit. Medium-term credit would be required to buy complementary agricultural equipment, and medium and large-scale farmers would need credit to purchase on-farm irrigation equipment. Seasonal credit
would be required to buy agricultural inputs. All credit would be financed by the Brazilian official credit system or by commercial banks.

**Implementation Schedule and Status of Project Preparation**

3.24 Project implementation would begin in 1990 and would be completed within five years. This schedule takes into account the Executing Agencies' capacity to build infrastructure works and the time needed to carry out initial farmers' settlement and agricultural development activities. It would require that the electrical infrastructure necessary to provide energy to the irrigation schemes would be installed before completion of the major irrigation infrastructure. To this effect, CCDEVASF, DNOCS and DNOS have signed agreements, satisfactory to the Bank, with COELBA, COELCE, and CEPISA, respectively, for the provision of the energy required by the irrigation schemes. The proposed implementation schedule is presented in Chart 1, Annex VIII.

3.25 International joint ventures of consulting firms, supervised by the USBR, have prepared feasibility studies and are currently working on the preparation of detailed engineering designs for the six irrigation schemes. The basic bidding documents for ICB for construction of civil works and acquisition of equipment were reviewed by the Bank during negotiations.

3.26 The Federal Government has already acquired the lands of the Formoso H, the Russas, and the Tabuleiros Litoraneos irrigation schemes, and issued the expropriation decree for the Guadalupe irrigation scheme. The irrigable land of the Barreiras Norte irrigation scheme would be acquired directly by CODEVASF through negotiations, currently underway, with the owners. A condition of effectiveness would be that CODEVASF, DNOCS and DNOS would have acquired all remaining project irrigable lands.

**C. Project Organization**

**Federal Level**

3.27 The project's institutional development objectives focus on long-term institutional improvements as well as on project management and implementation. In relation to the long-term improvements, the project would assist in developing a capability in SEPRONI to establish national policies and supervise the implementation of the National Irrigation Program. In terms of project implementation, the proposal is based on a design that holds central management (SEPRONI) accountable for results, while giving the federal executing agencies (CODEVASF, DNOCS and DNOS) autonomy to implement the project.

3.28 The long-term institutional improvements under the project are consistent with the Subsector Review recommendations and include: the maintenance of a Technical Office in SEPRONI; the creation of a directorate for agricultural operations in DNOCS; and the preparation of a staff development and training program for DNOCS. In SEPRONI, a solid Technical Office (Escritorio), utilizing existing PRONI staff, would be maintained whose functions would include: (a) updating of sectoral strategies, policies and programs and preparation of general studies related to irrigation development; (b) planning and monitoring of program implementation and performance studies, financial planning, and periodic
performance review of institutions active in the subsector; and
(c) preparation of a Technical Manual and Standards for use by the
irrigation agencies (CODEVASF, DNOCS, DNOS and state irrigation
organizations). For the first two activities, SEPRONI professional staff
would be assisted by U.S.B.R. short-term consultants (para. 3.22) for
eighteen months in the areas of water resources planning, irrigation
engineering and technologies, data processing, project analysis, and
private irrigation districts organization. The Directorate of Agricultural
Operations in DNOCS would oversee the management of agricultural
development in irrigated areas in accordance with the strategy
(decentralization to beneficiaries and maximum private sector
participation) recommended in the Subsector Review. The DNOCS staff
development and training program would aim to support the transition, also
recommended in the Review, away from socially-oriented settlement projects
towards production-oriented private sector irrigation development. During
negotiations, the Federal Government provided assurances that: (a) SEPRONI
would maintain the Technical Office with structure, functions and staffing
satisfactory to the Bank; (b) MINAGRI would submit for final consideration
to the appropriate branches of the Government a proposal for the creation
in DNOCS of a Directorate for Agriculture Operations no later than October
31, 1990, and would maintain the existing Special Group for Hydro-
agricultural Operations until the Directorate is created; and (c) DNOCS
would prepare a staff development and training program satisfactory to the
Bank, no later than June 30, 1990.

3.29 A special Project Coordinating Unit has been created within
SEPRONI, with structure, functions and staffing, including the appointment
of a project coordinator, all satisfactory to the Bank, to provide general
coordination for project implementation. The Unit would: (a) assist the
executing agencies in multiyear and annual planning for the project and
ensure consistency with sector policies and guidelines; (b) provide
technical implementation assistance to the executing agencies;
(c) supervise implementation of the irrigation program; (d) organize a
unified project monitoring system and impact evaluation activities; and
(e) advise the Secretary regarding annual policy and funding decisions with
respect to the project. The Unit consists of a Coordinator, three
professional staff plus administrative support staff. In addition, a
Management Committee consisting of the Special Secretary for Irrigation and
the heads of the three Executing Agencies has been established. This
Committee would meet periodically to evaluate the execution of the six
irrigation schemes, and to make decisions on issues presented to them by
the Project Coordinating Unit. During negotiations, the Federal Government
provided assurances that the Coordination Unit would be satisfactorily
maintained throughout the project implementation period.

3.30 In accordance with the subsector review recommendations (para.
2.11), during the construction phase, CODEVASF, DNOCS and DNOS would assume
overall responsibility for execution of the irrigation and drainage works.
CODEVASF would be in charge of the Bahia State irrigation schemes (Formoso
H, and Barreiras Norte), DNOCS of the Ceará irrigation schemes (Acará, and
Tabuleiros de Russas), and DNOS of the Piauí irrigation schemes (Guadalupe,
and Tabuleiros Litoraneos) where it has already begun construction. Later,
during the agricultural production phase, only CODEVASF and DNOCS would be
involved in supporting the irrigation districts. CODEVASF would work on
the irrigation districts located within the Sao Francisco River Basin
(Formoso "H", and Barreiras Norte), and DNOCS, on the districts located elsewhere in the semi-arid region (Acaratá, Tabuleiros de Ruassas, Guadalupe and Tabuleiros Litoraneos). Project Management Units would be established in each of the Executing Agencies, reporting directly to the heads of the Agencies. These Units would plan, coordinate and monitor activities related to farmer selection and settlement, construction and the initial period of project operation. Each Management Unit would maintain a Field Unit in each of the irrigation schemes, responsible for on-site project execution. It would also be responsible for setting in motion each irrigation district with a view towards making the district a private autonomous entity wholly responsible for the management of the irrigation scheme (paras. 3.32 to 3.36). During negotiations, the Federal Government provided assurances that: (a) it would enter into a satisfactory Implementation Agreement with the participating agencies setting forth respective responsibilities, and that the Implementation Agreement would not be changed without the Bank's approval; and (b) on completion of construction by DNOS of the Guadalupe and Tabuleiros Litoraneos irrigation schemes, it would cause DNOS to transfer to DNOCS, in a manner satisfactory to the Bank, full responsibility for overall management of both irrigation schemes. Signature of the Implementation Agreement would be a condition of loan effectiveness.

3.31 A number of measures to strengthen the Executing Agencies to implement the project have already been introduced. CODEVASF, DNOCS and DNOS have created their Project Management Units. Qualified staff as chiefs of the Coordination Units have also been appointed by the Executing Agencies. During negotiations, CODEVASF and the Federal Government provided assurances that CODEVASF, DNOCS and DNOS would employ, at all times during the implementation of the project, chiefs of the Management Units and residents to head the Field Units, with qualifications, experience and terms of reference acceptable to the Bank.

Irrigation Districts Organization

3.32 The irrigation districts would be responsible for the overall management of the irrigation schemes, including operation and maintenance of the project works and the provision of support services to its members. The Irrigation Districts would be private associations under Brazilian Law and their members would be project beneficiaries. The districts would become operational as soon as possible after farmer selection and settlement, in order to facilitate the early participation of the projects' beneficiaries. Operational costs would be financed by the project on a declining basis for up to three years (paras. 3.11 and 3.18) and charged to the farmers. Afterwards, operation and maintenance, and farmers services would be fully taken over by the districts by about 1997. Because the districts would be expected to play major roles in project execution, but at the same time remain small institutions, their own staff would be limited, and specialized firms would be recruited to provide services for farmers and to operate and maintain the subprojects' irrigation works, except for the main pumping plants and canals, which would be operated and maintained by the Executing Agencies. The districts' Governing Boards would have five to seven members: three to four representatives of small and medium beneficiaries (qualified irrigators and agricultural technicians), one to two representatives of the large farmers and one representative of the Rural Workers Union. The Executing Agencies would not vote, but would have veto power over the decisions of the Boards for a
period of five years. The districts would be composed of three divisions: Production; Operation and Maintenance; and Administration and Finances. The District Boards would appoint General Managers who would hire the heads of the three divisions, with the approval of the Boards. The remaining staff would be hired jointly by the General Managers and the heads of the divisions.

3.33 The Agricultural Production Division of each district would program and carry out activities related to agricultural extension and technical assistance to farmers and assist members in marketing or exporting their products (para. 3.19). It would monitor marketing conditions, look for outlets, negotiate contracts, group merchandise and arrange for pickup, transportation and delivery. Each district would subcontract these support services for the farmers, including technical assistance and marketing activities, with specialized consulting entities no later than three months after its establishment (para. 3.19).

3.34 The Operation and Maintenance Division would carry out activities related to: (a) water delivery to each farm; (b) water measurement at farm level within the irrigation scheme; and (c) operation and maintenance of the irrigation works. Each district would subcontract the operation and maintenance services no later than three months after its establishment (3.20).

3.35 The Administration and Finance Division of the district would keep the accounts of the districts: revenues incurred mainly from sales of services to members (supply of inputs, soil preparation, water charges) and expenses including operating expenses, repayment of the operation and maintenance expenses incurred by the executing agencies, reposition of equipment, and capital costs.

3.36 Potential local candidates for the positions of General Managers of the districts have already been identified by the Executing Agencies. The selected ones would be trained in the USBR Water Districts for a six-month period during 1990. Related costs for training would be financed by the Northeast Irrigation Engineering Project (Loan 2680-BR) (para 3.18).

Accounts and Auditing

3.37 Each of the participating agencies would maintain a separate account of its project expenditures to be audited annually by public or private auditors, acceptable to the Bank. Copies of the audit report would be provided to the Bank within six months following the close of the project’s fiscal year. The audit report would convey the auditor’s opinion on the adequacy of procedures used for the preparation and verification of statements of expenditures (SOEs) and their accuracy, eligibility for financing in accordance with compliance with legal agreements, and the standard of record-keeping and internal controls. The Special Account (para 3.50) would be audited by independent auditors satisfactory to the Bank. During negotiations, the Federal Government provided assurances on these matters.
Monitoring

3.38 An information and monitoring system organized and managed by SEPRONI would be financed by the project to improve the management of the implementation and operation and maintenance of the six project irrigation schemes. The system would be used for decision-making and is intended to provide the timely reports required at the different levels of the project organization. Only data needed, in a readily usable form, would be produced by the system. The information would also be used for internal operation and matters related to interaction among cooperating agencies, and to compare actual accomplishments with goals and objectives. SEPRONI's establishment of the information and monitoring system, satisfactory to the Bank, would be a condition for loan effectiveness. The Federal Government provided assurances during negotiations that the SEPRONI would submit semi-annual and annual progress reports to the Bank no later than three months after the close of each respective semester or fiscal year.

D. Project Costs and Financing

Costs

3.39 The total project cost, including taxes of about US$44.4M, has been estimated at US$465.0 M over the five-year implementation period of the project. Because the detailed engineering is substantially completed, (para. 3.25) 5% to 10% physical contingencies, depending on the scheme, for civil works and goods has been added to the base costs. Price contingencies of 7.2% in 1990, and 4.4% onward have been added to the base costs plus physical contingencies. It is assumed that periodic local currency devaluations would compensate for any differences between the projected US dollar and local inflation rates. Recent experience indicates that this assumption may not be valid in some cases; increases in local currency costs for civil construction over the last year have exceeded the rate of devaluation of the local currency. It is, however, uncertain as to whether and to what extent this trend would continue in the future. Therefore, project costs would be carefully monitored throughout the project implementation period. In the event that this trend continues, it would become necessary for the Government to finance these cost overruns, and the Bank, if needed, would reduce its disbursement percentages to maintain participation through project completion. Project costs and annual phasing of investments are summarized in the Loan and Project Summary and in Annex VII.

Financing Plan

3.40 The proposed Bank loan of US$210 M equivalent would finance 50.0% of total estimated costs net of taxes or 45% of total project costs. The loan would finance 100% of the direct and indirect foreign exchange costs and about US$86.5 M of local costs. The loan would be for 15 years, including a five-year grace period, and would bear interest at the Bank’s standard variable rate. The Bank loan would be made to the Federative Republic of Brazil, which would carry the foreign exchange risk and provide counterpart funds as necessary to complete the project. The loan closing date would be June 30, 1995. Project funds would be provided by the Federal Government to SEPRONI and the executing agencies on a grant basis. Funds made available to state power companies, to finance the construction
of electric networks, would be accounted for as an equity contribution in the name of the executing agencies. To ensure that sufficient and timely funds would be available to support the project, the Federal Government provided assurances at negotiations that: (a) it would make loan funds available to CODEVASF under a satisfactory Subsidiary Agreement to be signed between it and CODEVASF, and the Subsidiary Agreement would not be changed without the Bank's approval; (b) it would make loan funds available to SEPRONI, DNOCS and DNOS under financial arrangements satisfactory to the Bank, and these arrangements would not be changed without the Bank's approval; (c) the Treasury would make available to MINAGRI all funds for expenditures to be financed by the Government or from the loan, in accordance with the timetable and within the time period set for in the project implementation schedule of the annual plan (Plano de Aplicação, agreed upon by the Minister of Agriculture and the Treasury); (d) such funds would be made available to each Executing Agency in accordance with the amounts and timetable in the relevant Annual Operating Plans (POAs); and (e) CODEVASF, DNOCS and DNOS would provide to SEPRONI their draft POAs each year so that the SEPRONI can consolidate the POAs and submit a consolidated POA to the Bank, no later than June 30 of each year, for its review and comments. Conditions of effectiveness would be that the Subsidiary Agreement with CODEVASF and the financial arrangements with SEPRONI, DNOCS and DNOS had been entered into and that the Government would have allocated adequate funds from its proposed fiscal year 1990 budget to implement the 1990 consolidated POA.

**Procurement**

3.41 Procurement arrangements are summarized in the table below:

<table>
<thead>
<tr>
<th>Procurement Arrangements (US$ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Project Element</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Civil Works</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Goods and Equipment</td>
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<td></td>
</tr>
<tr>
<td>Consultants and</td>
</tr>
<tr>
<td>Other Services</td>
</tr>
<tr>
<td>Operating Costs</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Note:** Figures in parenthesis are the respective amounts (including contingencies) expected to be financed by the Bank.

3.42 Contracts for works above US$5.0 M and contracts for goods and equipment above US$300,000 would be awarded through International Competitive Bidding (ICB). These contracts would include irrigation works;
hydro-electro-mechanical equipment; electrical equipment; on-farm irrigation and agricultural equipment. Hydro-electro-mechanical equipment would be supplied to the irrigation works contractors for installation. Operation and maintenance equipment would also be grouped, whenever possible, into contracts valued at US$300,000 or more and would be procured through ICB. Procurement through ICB would represent about 78% of total procurement of goods and equipment under the project.

3.43 Contracts for works below US$5.0 M would be procured under Local Competitive Bidding (LCB), with procedures satisfactory to the Bank, and refer to: land clearing; initial soil improvement; and construction of buildings. The aggregate value of these works is estimated at about US$29.8M (CODEVASF, US$7.0 M; DNOCS, US$10.4 M; and DNOS, US$12.4 M). Contracts for goods and equipment below US$300,000 would be procured under local competitive bidding, with procedures satisfactory to the Bank; they would consist of construction materials and miscellaneous equipment. The aggregate value of the relevant contracts would not exceed US$6.6 M (CODEVASF, US$1.9 M; DNOCS, US$2.3 M; and DNOS, US$2.4 M).

3.44 Consultant services would be employed following Bank Guidelines for the Use of Consultants' (August 1981) for the preparation of construction designs and supervision of construction of the six public irrigation schemes. The consultant contracts will provide for some 1,650 man-months of consultants' services, and the costs of survey and construction quality control equipment, local transportation, local technicians and other minor items. Expatriate personnel would include senior level high caliber expertise in the fields of hydraulic design and construction supervision.

3.45 The operation and maintenance of the six irrigation districts and the provision of production support services to the farmers (including agricultural extension, technical assistance and marketing services), would also be provided by local and international consultants, and are estimated to require about 400 man-months. Expatriate personnel input would include senior level expertise in the fields of overall management of irrigation districts and technical assistance to farmers.

3.46 Office and extension equipment, furniture and other similar goods, estimated to cost less than US$40,000 per contract, would be awarded on the basis of evaluation and comparison of bids invited from at least three suppliers in accordance with procedures acceptable to the Bank; the aggregate value of such contracts would not exceed US$0.6 M (CODEVASF, US$0.2 M; DNOCS, US$0.2 M; and DNOS, US$0.2 M).

3.47 Civil works contracts over US$5.0 M and materials and equipment contracts over US$300,000 would be subject to prior review of bidding documents, bid evaluations, award proposals and final contracts. However, the first LCB procurement for works and the first for goods for each Executing Agency (CODEVASF, DNOCS and DNOS), irrespective of the size of the contracts, would be subject to prior review by the Bank of bid documents, bid evaluations, award proposals and final contracts. In total, Bank prior review would cover about 82.0% of the value of contracts financed under the project. Other contracts would be subject to selective post award review through the SOEs. Vehicles and computers are reserved procurement items: they would not be financed by the proposed loan, their
estimated cost has been excluded from total project costs, and the amount of the Bank loan has been reduced accordingly. The Federal Government and CODEVASF provided assurances at negotiations that the above procurement arrangements would be followed by CODEVASF, DNOCS and DNOS.

Disbursements

3.48 The proceeds of the loan would be disbursed against three categories, as indicated below:

<table>
<thead>
<tr>
<th>Category</th>
<th>Allocation of Loan Amount (US$ Million Equivalent)</th>
<th>Percentages of Total Expenditures to be Financed</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Civil Works</td>
<td>58.0</td>
<td>100% of foreign and 25% of local expenditures</td>
</tr>
<tr>
<td>(2) Goods and Equipment</td>
<td>115.0</td>
<td>100% of foreign and 40% of local expenditures</td>
</tr>
<tr>
<td>(3) Consultants Services and Technical Assistance</td>
<td>22.0</td>
<td>100% of foreign and 30% of local expenditures</td>
</tr>
<tr>
<td>(4) Unallocated</td>
<td>15.0</td>
<td></td>
</tr>
</tbody>
</table>

3.49 A five and one-half-year disbursement period is based on the works implementation schedules, and the period needed by most of the small farmers to initiate production. The proposed disbursement period is a little shorter than the disbursement period for the two first Bank loans to CODEVASF which were disbursed in eight and nine years (para. 2.14). However, the proposed disbursement period is realistic, since the three executing agencies have acquired considerable experience in construction, the bidding documents for major works and equipment were ready and reviewed at negotiations, and the Bank loan would not be disbursed against recurrent expenditures. Consequently, the preparation status, implementation schedule, and disbursement profile differ markedly from the previous projects.

3.50 To reduce Government prefinancing requirements, two special accounts would be established. A Cruzado Expenditure Special Account (CESA) would be opened in the Central Bank with an initial deposit of US$5.5 M. Withdrawals from CESA would be supported by the required documentation of Statements of Expenditures (SOEs). Except for the first CODEVASF, DNOCS and DNOS LCB contracts for goods and works, (para. 3.47), the Bank would disburse about US$9.5 M against Statements of Expenditures for contracts for works not exceeding US$5.0 M and for equipment contracts
not exceeding US$300,000, and operating costs. SOEs would be prepared by CODEVASF, DNOCS and DNOS in respect of their respective component of the project. The Coordinating Unit would be kept informed of these transactions by receiving copies of the disbursement requests sent by the executing agencies to the Central Bank. To facilitate disbursements in foreign currency, a Foreign Currency Special Account (FESA) would also be established in a commercial bank abroad, with an initial deposit of US$0.25 million. Withdrawals from FESA would be supported by the required documentation prepared by CODEVASF, DNOCS and DNOS in respect of their respective components of the project. The Coordinating Unit would be kept informed. A condition of disbursement would be for goods required under the project, that their importation has not been prohibited by the Government.

Cost Recovery

3.51 In accordance with the Federal Irrigation Law of 1979, and its regulations (Decree 89496), farmers who benefit from irrigation schemes are expected to pay water charges. These include a volumetric water charge to fully recover operation and maintenance costs, and a per hectare water charge to recover, the public investments in off-farm irrigation infrastructure. In addition, the Government is entitled to recover from small farmers public investments in land acquisition and on-farm irrigation equipment in real terms over a 25-year period with a 6% annual interest rate.

3.52 According to the financial analysis of the farm models (Annex IV) the small, medium and large size farmers would be able to pay water charges, in addition to paying for acquisition of land and improvement made on their farms, including interest charges, over a repayment period of 25 years. Under the project, the newly created irrigation districts would collect water charges and use these resources to pay CODEVASF and DNOCS for operation and maintenance of the main irrigation works and to finance their own services. SEPRONI is moving towards improving the enforcement of existing legal punitive measures, (including making the beneficiaries' land tenure right contingent on the payment of water charges), to increase the effectiveness of water charges collection by the irrigation districts. CODEVASF and DNOCS have issued satisfactory legal regulations to ensure that the water charges to be applied to all the beneficiaries of the project and covering investment, operation and maintenance costs, would be collected by the irrigation districts, and that these water charges would be applied beginning with the first year of cultivation increasing over a period of four years for each beneficiary, before levelling off in the fifth year. The Government also provided assurances at negotiations that: (a) water charges would be set at levels sufficient to fully recover operation and maintenance costs, and to recover public investments in off-farm infrastructure in real terms, plus a 3% rate of annual interest; and (b) water charges would be adjusted progressively, beginning with the first year of cultivation by each Project Beneficiary, according to a methodology satisfactory to the Bank, and proposed annual water charges would be reviewed with the Bank prior to making the adjustment.
E. Project Benefits

Agricultural Production

3.53 The total annual incremental production of the project would reach at full development, from Year 10 onwards, approximately: 59,000 tons of passion fruit, 46,800 tons of citrus, 55,000 tons of tomatoes, 58,000 tons of banana, 51,000 tons of grapes, 48,000 tons of onions, in addition to traditional crops such as 38,000 tons of beans, 62,800 tons of cotton, and smaller quantities of rice, maize and manioc. The impact of the project on agricultural production would result from irrigating land that previously sustained almost no economic activity.

Marketing

3.54 Most of the project's agricultural production would be marketed in the Northeast region and the rest in other regions of the country. At full development, however, it is estimated that 15% of the fruit and a small amount of the cotton would be exported. Recent marketing studies, carried out during project preparation, showed production deficits for the country in the year 2000 for the following products: beans, rice, tomatoes, grapes, mangos, passion fruit, citrus, bananas, garlic, potatoes and peanuts. The studies also showed that in the Northeast region the production deficits for these products would be more severe and that seasonal supply deficits would occur for onion and carrots. The annual incremental production of beans and rice produced by the project would be marketed locally, mainly by small private traders already active in the area. This would offset persistent deficits in the States of Piauí, Ceará and Bahia in recent years. Incremental cotton production in semi-processed and processed form would be utilized by the local textile industry or exported. Since the region is already a traditional cotton-growing area, marketing channels are well-established, and processing and manufacturing capacity is adequate. The annual incremental production of tomato, grapes, citrus and other fruits would be sold to local traders and would be marketed in urban centers located within a 1,200 km radius from the irrigation perimeters, which includes major cities such as Teresina, Salvador and Fortaleza. Any excess would be sold under group marketing contracts through existing channels to major urban centers, including Brasília, Belo Horizonte and São Paulo, for local consumption or export. Marketing services for newly created farmers' associations would be provided through the use of a specialized consulting firm (para. 3.19).

Employment and Farm Income

3.55 Expanded agricultural activities would create, at full development, total employment equivalent annually to 29,000 man-years of temporary or permanent jobs. This is a significant project impact considering present high rates of unemployment in semi-arid areas of the Northeast. Estimated financial rates of return for the seven farm models related to small scale farmers, range from 33% to more than 70%, while in the case of the eight models related to medium and large farmers, the estimated rates of return range from 23% to above 100%. In the financial analysis of the models, costs have been included for agricultural equipment, on-farm production costs, on-farm irrigation equipment and works, operation and maintenance of the irrigation perimeters, and cost
recovery for all government-financed off-farm irrigation infrastructure. Annual per capita income for the small scale farmers would increase with the project, from about one-third of the country's minimum wage, about US$200, to over US$1,000-1,600, assuming an average family size of six people.

F. Economic Analysis

Economic Rates of Return

3.56 The overall project's economic rate of return on productive investments has been estimated, for the six subprojects, at about 16% (Annex X). Rates of return for individual subprojects are as follows:

<table>
<thead>
<tr>
<th>Subproject</th>
<th>Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabuleiro de Russas</td>
<td>18.5%</td>
</tr>
<tr>
<td>Acarau</td>
<td>17.1%</td>
</tr>
<tr>
<td>Formoso</td>
<td>16.7%</td>
</tr>
<tr>
<td>Guadalupe</td>
<td>14.5%</td>
</tr>
<tr>
<td>Barreiras</td>
<td>14.2%</td>
</tr>
<tr>
<td>Tabuleiro Litorâneo</td>
<td>14.2%</td>
</tr>
<tr>
<td>Total Project</td>
<td>16.0%</td>
</tr>
</tbody>
</table>

3.57 Calculations of the economic rate of return considered an analysis period of 30 years. The cost stream includes all capital and recurrent costs. Taxes and other transfer payments, such as purchase of land, have been excluded from the cost stream. A shadow exchange rate was estimated and applied to all foreign exchange costs on both the cost and benefit sides.

3.58 The benefit streams include only the net value of agricultural production. Economic producer prices were derived for rice, cotton and citrus taking into account transportation and processing costs as well as future price trends as indicated by Bank forecasts. Market farmgate prices were used for all other crops. Production costs were then deducted from the gross value of production to obtain the net value of production. Production costs include labor and other farm inputs. Labor, both family and hired, was valued at a shadow rate ranging from 40% to 70% of the market rate, depending on the employment alternatives and their estimated opportunity costs in each subproject. Economic prices were derived for the most frequently used fertilizers, while market prices were used for all other inputs.

Sensitivity Tests

3.59 The economic rate of return appears moderately more sensitive to reductions in the value of production than to increases in costs; when the value of production decreases by 14%, or costs increase by 39%, the ERR becomes equal to the assumed opportunity cost of capital of 12%. The sensitivity analysis of each individual project, however, shows that three projects, Tabuleiros Litorâneos, Guadalupe and Barreiras, are very sensitive to variations in the value of production; there, a decrease of the value of production by about 8% generates an ERR of 12%. A 12% increase in the value of the shadow exchange rate marginally increases the rate of return for all projects.
G. Project Risks

3.60 The risks associated with the project are: (a) delays and shortfalls in counterpart funding; (b) institutional inefficiency; and (c) potential farmer reluctance to pay water charges for full recovery of capital and operation and maintenance costs. To minimize the risk of inadequate counterpart funds, during negotiations agreements were reached with the Federal Government on funding procedures and the amount of funds which would be included in the fiscal budget for this project. To ensure competent and efficient implementation, Project Management Units would be established in each of the Executing Agencies, reporting directly to the head of the agency; field units would be also established at each project site. The project would also include considerable technical assistance to help further develop federal agencies' implementation capabilities, including DNOCS' capability to oversee and support the production-related activities implemented by the irrigation districts. The local collection of water charges by the irrigation districts and improved enforcement of legal punitive measures to be set forth in the contracts to be signed with the farmers, should lead to effective cost recovery.

IV. SUMMARY OF AGREEMENTS TO BE REACHED AND RECOMMENDATIONS

4.01 Conditions for loan effectiveness would be that:

(a) SEPRONI would sign an agreement, satisfactory to the Bank, for the provision of technical assistance to the National Irrigation Program and would prepare a proposal acceptable to the Bank for the provision of technical assistance to DNOCS (para. 3.22);

(b) CODEVASF, DNOCS and DNOS would have acquired all remaining project irrigable lands (para. 3.26);

(c) The Federal Government and the participating agencies would enter into an Implementation Agreement satisfactory to the Bank (para. 3.30);

(d) SEPRONI would establish a system satisfactory to the Bank, for monitoring of project activities (para. 3.38);

(e) the Subsidiary Agreement between the Federal Government and CODEVASF and the financial arrangements between the Federal Government and SEPRONI, DNOCS and DNOS would have been entered into (para. 3.40); and

(f) the Government would have allocated adequate funds from its proposed fiscal year 1990 budget to be made available to SEPRONI, DNOCS, DNOS and CODEVASF to implement the 1990 consolidated POA (para. 3.40).

4.02 A condition of disbursement would be for goods required under the project that their importation has not been prohibited by the Government (para. 3.50).
4.03 At negotiations, the Federative Republic of Brazil provided assurances that:

(a) DNOCS would complete beneficiary selection in each of its irrigation schemes, by December 31, 1991 or by a later date to be agreed to by the Bank, and immediately thereafter, organize an irrigation district in each scheme, and maintain it with an organization, structure and functions - including a General Manager and competent staff in adequate numbers - all acceptable to the Bank (para. 3.18);

(b) DNOCS would cause each irrigation district to subcontract, no later than three months after its establishment unless otherwise agreed to by the Bank, the provision of extension and marketing services to a specialized entity with satisfactory qualifications and experience (para. 3.19);

(c) DNOCS would cause each irrigation district to subcontract, no later than three months after its establishment unless otherwise agreed to by the Bank, the operation and maintenance of irrigation works to a specialized entity with satisfactory qualifications and experience (para. 3.20);

(d) DNOCS would sign a satisfactory agreement with SUCAM, no later than December 31, 1991, to carry out a campaign against water-borne diseases in the project area (para. 3.21);

(e) the DNOCS technical assistance agreement would be entered into no later than May 30, 1990 (para. 3.22);

(f) SEPRONI would maintain its Technical Office with structure, functions and staffing satisfactory to the Bank (para. 3.28);

(g) DNOCS would maintain a Special Group for Hydro-agricultural Operations until a formal Directorate of Agricultural Operations is created (para. 3.28);

(h) MINAGRI would present for final consideration to the appropriate branches of Government a proposal for the creation in DNOCS of a Directorate of Agricultural Operations to oversee the management of agricultural development in irrigated areas, no later than October 31, 1990 (para. 3.28);

(i) DNOCS would prepare a satisfactory staffing, training and development plan by June 30, 1990 (para. 3.28);

(j) A satisfactory Project Coordination Unit would be maintained within SEPRONI throughout the project implementation period (para. 3.29);

(k) it would enter into a satisfactory Implementation Agreement with SEPRONI, CODEVASF, DNOCS and DNOS, and the Agreement would not be changed without the Bank's approval (para. 3.30);
(l) on completion of construction by DNOS of the Guadalupe and the Tabuleiros Litoraneos irrigation schemes, the Government would cause DNOS to transfer to DNOCS, in a manner satisfactory to the Bank, full responsibility for overall management of both irrigation schemes (para. 3.30);

(m) (i) separate project accounts would be maintained by each participating agency and audited annually according to practices satisfactory to the Bank; (ii) terms of reference for the auditors would include verification of expenditures made under statements of expenditures (SOEs); and (iii) audit reports would be submitted to the Bank within six months of the close of each fiscal year (para. 3.37);

(n) SEPRONI would submit to the Bank semi-annual and annual progress reports no later than three months after the close of each respective semester or fiscal year (para. 3.38);

(o) (i) it would make loan funds available to CODEVASF under a satisfactory Subsidiary Agreement to be signed between it and CODEVASF, and the Subsidiary Agreement would not be changed without the Bank's approval; (ii) it would make loan funds available to SEPRONI, DNOCS and DNOS under financial arrangements satisfactory to the Bank, and these arrangements would not be changed without the Bank's approval (3.40);

(p) (i) the Treasury would make available to MINAGRI all funds for the project in accordance with the timetables and within the time period set forth in the project implementation schedule of the annual plan, and MINAGRI would make available such funds to each Executing Agency in accordance with the amounts and timetables of the Annual Operating Plans; and (ii) CODEVASF, DNOCS and DNOS would provide to SEPRONI their draft POA each year, so that SEPRONI can consolidated the POAs and submit a consolidate POA to the Bank for its review and comments no later than June 30 of each year (para. 3.40);

(q) procurement arrangements outlined in paras. 3.41-3.47 would be followed;

(r) water charges would be set at levels sufficient to fully recover operations and maintenance costs, and to recover public investments in off-farm infrastructure in real terms, plus a 3% rate of annual interest (para. 3.52); and

(s) water charges would be adjusted progressively, beginning the first year of cultivation by each project beneficiary, according to a methodology satisfactory to the Bank and proposed annual charges would be reviewed with the Bank prior to making the adjustment (para. 3.52).

4.04 At negotiations, CODEVASF provided assurances that:

(a) it would complete beneficiary selection in each of its irrigation schemes by December 31, 1991, or by a later date to be agreed to
by the Bank, and immediately thereafter organize an irrigation district in each scheme, and maintain it with an organization, structure and functions - including a General Manager and competent staff in adequate numbers - all acceptable to the Bank (para. 3.18);

(b) each irrigation district would subcontract no later than three months after its establishment, unless otherwise agreed to by the Bank, the provision of extension and marketing services to a specialized entity with qualifications and experience satisfactory to the Bank (para. 3.19);

(c) each irrigation district would subcontract operation and maintenance of irrigation works to a specialized entity, with experience and qualifications acceptable to the Bank, no later than three months after its establishment unless otherwise agreed to by the Bank (para. 3.20); and

(d) it would sign a satisfactory written agreement with SUCAM no later than December 31, 1991, to carry out a campaign against water-borne diseases in the project area (para. 3.21).

4.05 At negotiations CODEVASF and the Federal Government provided assurances that:

(a) CODEVASF, DNOCS, and DNOS would implement the resettlement plans in accordance with the terms defined in the resettlement plans agreed with the Bank (para. 3.10);

(b) CODEVASF, DNOCS and DNOS would employ, at all times during the implementation of the project, chiefs of the Management Units and residents to head the Field Units, with qualifications, experience and terms of reference acceptable to the Bank (para. 3.31); and

(c) CODEVASF, DNOCS, and DNOS would follow the procurement arrangements described in paragraphs 3.41 to 3.47.

4.06 Subject to the above agreements, the proposed project would be suitable for a Bank Loan of US$210 M equivalent with a term of 15 years, including a 5-year grace period.
CODEVASF IRRIGATION SCHEMES

A. FORMOSO "H" IRRIGATION SCHEME (4,875 ha)

Location and Physical Resources

1. The project is located in Western Bahia, about 25 km from Bom Jesus da Lapa on the right bank of the Correntine River and close to its confluence with the São Francisco River. A paved federal road gives easy access to the area. BR-349 is the southern border of Formoso "H". The distance by road from Formoso to Brasilia is about 700 km and to Salvador 500 km.

2. CODEVASF owns the Formoso "H" area, which is presently unoccupied and has no infrastructure. The area borders to the east on the Bank co-financed Formoso "A" irrigation scheme (Loan 2719-BR) and to the west a private cotton production development under center pivot irrigation.

3. Mean annual rainfall in the Formoso "H" area amounts to 837 mm. The climate is characterized by prolonged dry periods and irregular rainfall patterns during and in between years. About 82% of the precipitation falls in a 5-month period between November and March. Mean monthly temperatures are around 25.6°C and show only small variations throughout the year. Maximum potential evapotranspiration estimated by the Hargreaves method reaches 238 mm in September. Winds are normally mild with velocities below 2 m/sec. The project would draw its water from the Correntine River, a main tributary of the São Francisco River, with an annual mean flow of 214 m³/s and absolute minimum flow of 130 m³/sec recorded in 44 years of observation. Water requirements for the project during peak demand periods would amount to 6.05 m³/sec. Water from the Correntine River is of good quality for irrigation and has been classified as ClSI (U.S. Bureau of Salinity Classification.)

4. Formoso "H" has a slightly ondulating topography with slopes varying between 0 and 2°. A natural drain crosses the area in the SW-NE direction and ensures rapid evacuation of surface run-off waters. The soils are medium-textured latosols and podzols (77%), sandy soils (12%) and heavy hydromorphic soils (11%). Details on land suitability for irrigation are described in Annex IV.

Water Demand

5. Water demand was estimated based on potential evapotranspiration rates calculated by the Hargreaves method and from pan evaporation data (Class A - Pan - USBR) using whichever value was higher and applying crop coefficients as published in FAO handbook 24. Figures were adjusted for effective rainfall and based on 75% probability precipitation. The weighted
average peak water requirements of the project based on a 20-hour daily operation amounts to 1.41 l/sec/ha at the main pumping station, assuming irrigation efficiencies of 90% for the conveyance system, 90% for the distribution system, 55% for on-farm gravity irrigation, 70% for on-farm sprinkler irrigation and 85% for on-farm drip irrigation.

Off-Farm Irrigation Infrastructure

6. The project would irrigate a net area of about 4875 ha distributed in 18 sectors and 638 farm plots varying from 6.0 to 50.0 ha. Water would be pumped from the Corrente River. The main pumping plant (EB1) at the most downstream point of the project area would have 2 groups of pumps to lift water to 2 main canals, CPI and CP2, at different elevations. CPI, the lower canal, would deliver water to the low-lying gravity-irrigated heavy hydromorphic soils near the river. A secondary canal system (CS1 through CS6) would deliver water to individual 6 ha plots. CPI would also serve 10 large farms (40ha-50ha) on heavy soils and on light soils. CP2, the upper canal, would deliver water to (a) a secondary canal (CS7) that would supply the remainder of the large 40ha to 50 ha farms and (b) a booster pumping station (EB2). The latter would pump water to the CP3 main canal. The conveyance systems also include four pressure pipelines and a 700 m siphon. The CP3 canal would supply 14 secondary pressurization pumping plants, each serving one hydraulic sector. Within the hydraulic sectors, pressurized water would be delivered to individual farm turnouts (6ha to 8ha net). Each individual turnout would have a valve and measuring device. The pressurized pipe system would also be equipped with 'Bermad' type valves (one for 6 farms) to keep the pipelines full of water in case farm turn out were not closed when pressurization pumps are turned off. The main pumping stations (EB1 and EB2) would have vertical pumps. Automatic control would be effected by means of water levels in the canals at the terminuses of the pressure lines, using a "Bival" type system. Pressurized pumping plants would have horizontal pumps. Automation would be controlled by pressure sensors in the downstream pipe systems leading to the hydraulic sectors. Canals would be concrete-lined and their control gates motorized and monitored in a central control facility. Automation of gates would be by a downstream control system with water level sensors.

On-Farm Irrigation Works

7. Areas with heavy hydromorphic soils would be gravity-irrigated (plots of 6 ha for small holders and 40 ha for large farms). These are flat lands which would require only a little land levelling. Private enterprises and large farmers (45 to 50) in light and medium soils would pump directly from the conveyance and distribution canals and install center pivots, conventional sprinkler or drip systems on their own account. Small holders (6ha to 8ha) on light and medium textured soils would receive pressurized water. They would irrigate by conventional sprinkler methods. A typical layout would include a buried main line and two fly lines, both 2" aluminum pipes, plus one spare line. Sprinklers would be spaced at 12 m x 18 m, operate at a pressure of 2.25 atm and have a discharge of 1.56 m³/h.
Complementary Physical Infrastructure

8. A 5.5 km dike with a maximum height of 2.20 m would protect the low-lying alluvial hydromorphic soils from flooding. The dike has been designed to protect against a 100 year flood. The area of hydromorphic soils would be provided with an interconnected system of open drains to evacuate run-off water from rainfall and irrigation. The remaining area would be served by natural drains with minor additions.

9. The project would finance the construction of 140 km access roads. All roads would be graveled. Energy would be supplied from the Formoso "A" substation presently under construction. Distribution within the project area would be through three-phase primary lines. Three-phase transformers would be installed to feed the pressurization pumping plants and service centers. Offices, storage facilities, workshops and equipment necessary for project operations and housing facilities for support staff would be provided at the service centers.

B. BARREIRAS IRRIGATION SCHEME (8,725 ha)

Location and Physical Resources

10. The project is located in western Bahia, some 12 km to the north of the city of Barreiras and along the Rio Grande. The federal road BR-020 crosses the project area. Road distance from Barreiras to Brasilia is 650 km and to Salvador 850 km.

11. The Barreiras project comprises three sub-project areas (Barreiras Norte, Riacho Grande and Nuppeba.) The town of São José do Rio Grande (5,000 inhabitants) is close to the project area and the village of Barra do Riacho (400 inhabitants) lies within it. Both have electricity for household consumption. Only São José do Rio Grande has a water supply system and neither of them have sewage infrastructure.

12. Mean annual rainfall in Barreiras amounts to 960 mm, 90% of which is concentrated in a 5-month period between November and March. The area suffers from long dry periods and irregular rainfall patterns during and in between years. Mean monthly temperatures are around 26°C and show only small variations during the year. Maximum monthly potential evapotranspiration reaches 199 mm in October. Winds are normally mild with velocities below 2 m/sec. The Rio Grande would be the water source for the Barreiras Irrigation Scheme. The project would pump less than 10 m³/sec during peak demand periods, which compares with a mean monthly flow of the river of 110 m³/sec and an absolute minimum flow of 60 m³/sec recorded in 23 years of observations. The water in the river is of good quality for irrigation purposes and has been classified as Cl-S1 (U.S. Bureau of Salinity Classification). The Barreiras project has an undulating topography with slopes of up to 6%. The area is well drained by natural waterways. Soils are medium textured. About 85% have uniform physiographic characteristics and are developed on sedimentary materials (red-yellow podzols) and the remaining 15% are low land with alluvial soils. (See Annex IV for information on land suitability for irrigation.)
**Water Demand**

13. The irrigation network has been designed to supply 1/sec/ha at farm level during the month of peak water demands. The above flow assumes a 20 hour operation of pumps and irrigation efficiencies of 75% for on farm sprinkling and 97% for water distribution in a closed pipe network. The designed system would be able to meet 80% of total estimated water requirements during the month of peak demand. Project benefits have been adjusted accordingly in the economic analysis.

**Off-Farm Irrigation Infrastructure**

14. The project would irrigate a net area of 8,725 ha distributed in three independent sub-projects: Barreiras Norte with 3,330 ha, Riacho Grande with 1,975 ha and Nupeba with 3,420 ha. Water for the project would be pumped from the Rio Grande by means of six pumping stations. These six plants together would have 23 vertical units with a lift of between 72 m and 91 m. An additional 4 booster stations, together representing 13 booster pumps, would lift the water an additional 15 to 21 m and allow for irrigation of the higher areas where pressure would be otherwise too small. Eleven pressure lines would discharge the water into six regulating reservoirs for subsequent delivery to buried pipelines leading to individual lots. All farmers would receive metered and pressurized water at their farm gates.

**On-Farm Irrigation Works**

15. Qualified settlers would receive 7.5 ha farms, farmers with technical agricultural background 15 ha and 22.5 ha units and private enterprises would occupy 30 to 80 ha farms. About 180 small holdings and squatters would be displaced by the project and settled on 2 ha and 4 ha irrigated farms (Annex V). About 80% of the area (6,972 ha) would be occupied by settlers and medium sized farmers and 20% (1,753 ha) by private enterprises. Each farm would have its own water meter and valve. The on-farm equipment of a typical 7.5 ha small holder unit would comprise a buried PVC mainline and two aluminum fly lines. Sprinklers would be spaced 12 m x 18 m, operate at a pressure of 30 m and discharge between 0.76 m³/h and 1.13 m³/h. Medium sized farms (15 ha and 22.5 ha) and large holders would develop their own on-farm system.

**Complementary Physical Infrastructure**

16. The project would construct surface drains to intercept and evacuate rainfall and irrigation runoff into natural waterways. Land preparation would include land clearing and the application of soil amendments. About 106 km of new roads would provide access to farms and project structures. The required energy would be provided by a transmission line (69 kv) under construction by CHESF, that will cross the project area. The project would provide 13.8 kv lines and transformers to supply pumping stations and service centers with electricity. The latter would have offices, storage facilities, workshops and equipment necessary for project operations and housing for support staff.
BRAZIL

NATIONAL IRRIGATION PROGRAM

NORTHEAST IRRIGATION PROJECT

DNQCS IRRIGATION SCHEMES

A. ACARAU IRRIGATION SCHEME (8,210 ha)

Location and Physical Resources

1. The Acarau project is located on the right bank of the Acarau River in Northern Ceará and lies within the boundaries of the Acarau, Marco, Santana and Morninhos municipalities. Access is through a single paved road which ends in the city of Acarau and links the project area with the federal roads BR-402 to Fortaleza (250 km) and BR-222 to Sobral (120 km). The project area lacks basic infrastructure. Houses in the adjacent areas lack water supply and sewage systems and have limited access to household electricity.

2. Mean annual rainfall amounts to about 878 mm. 90% of the precipitation falls between January and May. The area suffers from prolonged dry periods and irregular rainfall patterns within the year and between the years. Mean monthly temperatures are around 28°C with small variations throughout the year. October is the month of highest evaporation. Potential evapotranspiration during this month reaches 202 mm. Wind velocities measured during one year in the Acarau project area indicate significantly lower levels than those recorded in the city of Acarau closer to the coast. The average wind velocity in Acarau City is around 3 m/sec.

3. The project would draw water from the Acarau River, regulated by the following reservoirs: Araras (891 x 10^6 m^3), Edson Queiroz (248 x 10^6 m^3), Ayres de Souza (104 x 10^6 m^3), Forquilla (50 x 10^6 m^3) and Acarau Mirim (150 x 10^6 m^3). Deducting existing and planned water uses, the system would have sufficient water to irrigate at least 9,000 ha and, depending on the assumptions for water requirements and permissible shortages, possibly 15,000 ha. The proposed first phase development only contemplates the development of some 8,210 ha. The water of the Acarau system is of good quality and is now being used for irrigation without adverse effects.

4. The project area has a smooth to slightly undulating topography with slopes generally below 3%. Natural waterways provide good surface drainage. Soils are deep but light textured with high infiltration rates (120 mm/h) and low soil moisture storage capacities (8 cm/m). Surface textures are sandy loams and subsurface textures, sandy loams or sandy clay loams.
Water Demand

5. Water demand has been estimated based on potential evapotranspiration rates calculated by the Hargreaves method and applying FAO Handbook 24 crop coefficients. Figures were adjusted for effective rainfall and based on a 75% probability precipitation. Irrigation efficiencies have been assumed as follows: conveyance (90%), distribution system (90%), sprinkler irrigation (64%), and on-farm drip irrigation (90%). With these assumptions and based on a 20 hour daily operation, peak water demand at the main pumping station would amount to 1.52 l/sec/ha for sprinkler and 0.65 l/sec/ha for drip irrigated areas.

Off-Farm Irrigation Infrastructure

6. Headworks for the project would comprise a diversion dam across the Acarau River (max. height 5.75m) for accumulation of water during non-pumping hours and a main pumping station. Civil works of the pumping station would be sized to allow for future expansions, but equipment limited to meet the needs of the proposed project. The latter would include five equally sized pumps to lift 10.5 m³/sec of water 44.5 m. The pressure lines, about 1.6 km long, would discharge water into the main conveyance canal (CP) from where it would be distributed into about 50 km canal distribution network. Along the canals would be control structures and turnouts for each lot. Automation would be achieved with downstream water level sensors.

On-Farm Irrigation Works

7. The project comprises irrigation development for about 8,210 net ha to be farmed in between 2 and 8 ha (settlers), 16 ha and 80 ha production units with sprinkler and localized irrigation methods. Each lot would have its own individual operated pressurization units. Large holders (private enterprise) and medium sized farmers would develop their own on-farm systems. Small holders (8 ha) would be provided with on-farm works and sprinkler equipment. An 8 ha on-farm sprinkler system would include a small on-farm reservoir (20 m³), an individual pressurization pumping station (10 to 15 CV), a fixed buried PVC line and 3 fly lines. Sprinklers would be spaced 12 m x 18 m, operate at a pressure range between 20 and 22 m and sprinkler discharges vary from 1.6 m³/h to 2.9 m³/h. Drip irrigation would require an operating pressure of 10.5 m to 13 m and discharge 3.5 l/h per emitter.

Complementary Physical Infrastructure

8. The project would build a surface drainage system to evacuate run-off water into natural waterways. It also would construct some 60 km of access roads. Land preparation would involve land clearing, establishment of wind breaks and soil amendments. Energy for the project would be supplied from the transmission line Sobral-Acarau to be built by CHESF in 1990. The project would construct service centers with offices, storage facilities, workshops and equipment necessary for project operation and housing for support staff.
B. **TABULEIROS DE RUSSAS IRRIGATION SCHEME (10,500 ha)**

**Location and Physical Resources**

9. The project is located on the left banks of the Banabuiu and Jaguaribe Rivers, within the Municipalities of Russas and Morada Nova and Limoeiro in the State of Ceará. Federal Roads BR-116 from Fortaleza to Recife and BR-304 from Natal to Aracatia, in addition to state roads, provide easy access to the project area. The distance from Russas to Fortaleza is 162 km, to Natal 300 km and to Recife 803 km. Currently the project area is well provided with basic infrastructure. A federal road and two paved state roads cross the project area. Houses in the project area and in adjacent areas lack water supply and sewage systems and only some have access to household electricity.

10. Mean yearly rainfall amounts to 720 mm. Ninety percent of the precipitation falls between December and May. The area suffers from prolonged dry periods and irregular rainfall patterns within the year and between years. Mean monthly temperatures are around 27° C, with small variations throughout the year. Potential evapotranspiration in October reaches 250 mm. Wind velocity averages 2.5 m/sec but can reach up to 8.5 m/sec in December for a limited duration (one or two hours). The land has a slightly undulating topography with slopes generally below 3%. Natural waterways provide good drainage for runoff waters. Soils are deep but light textured with high infiltration rates (80 cm/h) and low soil moisture storage capacities (8 to 10 cm/m).

11. The Tabuleiros de Russas Irrigation scheme would be for the irrigation of 25,000 ha at full development. The project would only finance the construction of the first stage covering about 10,500 ha. The water would be pumped from the Banabuiu River, an affluent of the Jaguaribe River. The Jaguaribe basin is partially regulated by the following reservoirs: Banabuiu (1,690 x 10^6 m^3), Pedras Brancas (500 x 10^6 m^3) and Orós (2,100 x 10^6 m^3). An additional dam (Castanhão) with a 3,500 x 10^6 m^3 reservoir capacity has been planned and would fully regulate the Jaguaribe Basin. However, existing storage facilities guarantee a minimum flow of 20 m^3/sec at any time during the year which is more than sufficient to meet the needs of the proposed 10,500 ha project and allows for a sanitary flow in the river. The waters in the Jaguaribe river basin are of good quality and are being used by the private sector and in DNOCS projects for irrigation.

**Water Demand**

12. About 24% of the area would be irrigated by drip and 76% by conventional sprinkler irrigation. Water demand has been estimated on the same basis as the Acarau Irrigation Scheme (para. 5). The peak water demand at the main pumping station, based on these assumptions and on a 20 hour operation during peak demand periods, would amount to 1.55 l/sec/ha for areas under conventional sprinkler irrigation and 0.6 l/sec/ha for areas under drip irrigation.
Off-Farm Irrigation Infrastructure

13. Off-farm irrigation works include a (a) main pumping station (Q=13.3 m³/sec; H=42 m) on the Banabuiu river, immediately upstream of the Morada Nova diversion weir, (b) 800 m pressure line, (c) 17 km main conveyence canal (Q=32 m³/sec) and (d) irrigation distribution network. The main canal includes an 800 m aqueduct and has been sized to meet the needs of the proposed project and for future expansions of the project area. The project distribution network would comprise 13.4 km of main canal (Q=13.3 m³/sec), a secondary pumping station (Q=8 m³/sec; H=8 m) and a 72 km canal and 963 km low pressure pipe network. All canals would be concrete lined. Automation would be achieved by Neyrpic type gates with downstream control. Water would be delivered to farmgates at gravity pressure. The project would also provide irrigation kits (pumps and on-farm sprinkler equipment for 2 to 3 ha) for small holders in areas adjacent to the project area and along the river (Annex V).

On-Farm Irrigation Works

14. Farm sizes would vary from 2 ha to 100 ha. Medium and large farmers (operating above 8 ha) would irrigate by localized and sprinkler irrigation methods. They would develop their own on-farm systems. Small holders (less than 8 ha) would receive their holdings equipped with conventional sprinkler systems. The lay-out would be similar to the Acarau project (para. 7).

Complementary Physical Infrastructure

15. Surface drainage would be limited to minor works for evacuation of surface run-off into natural drains. Land preparation would include land clearing, establishment of wind breaks and soil amendments. The project would provide for 226 km of access roads. All roads would be gravelled. Electricity for the main pumping stations would be supplied through a 69 kv line to be furnished by COELCE. Approximately 16.9 km of 13.8 kv lines would supply energy to individual pumping plants within the project area. The project would also construct support centers with offices, storage facilities, workshops and equipment necessary for project operation and housing for support staff.
A. Guadalupe Irrigation Scheme (11,870 ha)

Location and Physical Resources

1. The Guadalupe scheme would cover a net area of about 14,870 ha at full development. DNOS is presently completing construction of irrigation works to irrigate some 3,000 ha with center pivots (Block 1, phase 1). The proposed 11,870 ha Bank cofinanced project would benefit from constructed headworks, mainly civil works of the main pumping station (EBP) and a 1.32 km conveyance canal for irrigation of part of the project area (4,100 ha, Block 1 - phase 2). The project is located in the State of Piauí, to the south of the Boa Esperança Reservoir and close to the City of Guadalupe. The federal road BR-343 connects Guadalupe with Teresina (360 km). The road is paved but in poor condition and in need of maintenance. A gravel surfaced state road (PI-218), also in poor condition and in constant need of repair for year-round use, links the project area with Floriano (90 km). The project area is partly covered by natural vegetation or dedicated to subsistence crops and lacks all basic infrastructure. Mean annual rainfall amounts to 1100 mm with about 85% of it occurring between October and March. The area has a distinct dry period of about 5 months. Mean monthly temperatures average 26.50°C but reach maximum levels of 29°C in September. Winds are mild and generally below 2 m/sec. Maximum potential evapotranspiration calculated by the Hargreaves method reaches 183 mm in October. The project has ample water supply from the Boa Esperança Reservoir (14,800 x 10^6 m^3). Yearly water demands for the proposed project (11,870 ha) and the first phase irrigation development presently under construction (3,000 ha) would be at about 200 million cubic meters. The Esperança Dam has been constructed for power generation with a reserve of 400 million cubic meters per year for irrigation purposes. The project would only demand 50% of the resources allocated for irrigation purposes. The water is of good quality for irrigation purposes. The topography in the area is flat to gently undulating with slopes generally below 4%. Natural creeks cross the area and provide adequate surface drainage. Soils are mainly light to medium textured red-yellow podzols with infiltration rates of around 80 mm/h and moisture holding capacities at or above 8 cm/m.

Water Demand

2. The irrigated area under the project would comprise a net area of 11,870 ha distributed in two separate units of 4,100 ha and 7,770 ha. The area would be allotted in 8 ha farms for qualified settlers, 16 ha for farmers with technical agricultural background and 30 ha lots for private enterprises. Displaced small holders would be resettled on 2 to 4 ha lots (Annex V). The 2 to 8 ha farms would be irrigated by conventional sprinkler systems and larger units depending on the choice of their owners, by conventional sprinklers and center pivots. Water demands have been estimated
based on potential evapotranspiration calculated by the Hargreaves method by applying FAO recommended (Handbook 24) crop factors. Irrigation efficiencies have been assumed at 95% for conveyance and distribution, and 70% for conventional sprinkler irrigation. With the above assumptions and based on 20 hour daily operation, peak water demands at the main pumping station would amount to 1.2 l/sec/ha.

Off-Farm Irrigation Infrastructure

3. Water for the Guadalupe project would be pumped from the Boa Esperanza Reservoir by means of two pumping stations serving Block 1, Stage 2 (4,100) and Block 3 (7,770 ha).

4. Block 1, Stage 2 (4,100 ha). The main pumping plant (EBP) for Block 1 would have 8 vertical pumps to lift 9.6 m³/sec 33 m high. Three pressure lines of about 1,100 mm in length would discharge water into a regulating reservoir equipped with control gates to release water according to irrigation demands. The two main canals CP1 and CP2 would serve about 7,100 ha including the 4,100 ha to be financed by the project. Several works are already under construction and the project would only provide 4 vertical pumps of 1.2 m³/sec and a pressure line for the main pumping station. Additional off farm irrigation infrastructure would include: (a) a pumping station (EBS) on the CP2 canal to lift 4.4 m³/sec an additional 42 m; (b) a 5.4 km lined canal network; and (c) 6 pressurization pumps and a pipe network for delivery of pressurized water at the farmgates (one pump for between 428 ha and 840 ha).

5. Block 3 (7,770 ha). Block 3 would have its own pumping station at the Boa Esperança Reservoir (EBP3) equipped with 16 vertical pumps to lift 10.0 m³/sec 85 m. Three 3,300 m pressure lines would discharge the water into a 19 km lined canal network. Fourteen pressurization pumps along the canal (12 serving about 500 ha each and 2 some 1,100 ha each) would pressurize a pipe distribution network (H = 55 m) and deliver pressurized and metered water to individual farms.

On-Farm Irrigation Works

6. The project area would be occupied by settlers with up to 8 ha lots, medium sized farmers (16ha) and large holdings. Displaced small holders would receive 2 to 4 ha lots (Annex 5). Medium and large holders would install their own on-farm systems and may opt for localized or sprinkler irrigation methods, including centre pivots. Settlers would be provided with conventional sprinkler systems comprising a buried main line and three fly lines. Sprinklers would be spaced 18 x 18m and would operate at a pressure of 25 m.

Complementary Physical Infrastructure

7. The project would provide collector and interceptor drains to evacuate surface runoff into natural waterways. Land preparation would include clearing of the natural vegetation and application of soil amendments. It would also provide 235 km of access roads to all farms. Electricity for the project would be supplied from the Boa Esperança power plant via a 12 km transmission line to the project’s primary substation. Distribution within the project area would be through a three-phase primary
line. Three-phase transformers would be used to supply the pumping stations and service centers. The latter would include offices, storage facilities, workshops and equipment necessary for project operation and houses for support staff.

B. **Tabuleiros Litorâneos Irrigation Scheme (7,510 HA)**

**Location and Physical Resources**

- The Tabuleiros Litorâneos Scheme would cover a net area of about 8,300 ha at full development. Headworks for a 2,100 ha first phase and on-farm works for 790 ha have already been constructed and are in operation. The proposed 7,510 ha Bank cofinanced project would: (a) provide the distribution network and on-farm irrigation and drainage works for the remaining 1,390 ha of the phase 1 area to be allotted in 32 ha units to large farmers and (b) expand the irrigated area by an additional 6,120 ha, including a 2,200 ha EMBRAPA research station. The new area would be settled in 8 ha, 16 ha and 32 ha farms. The project is located on the right bank of the Parnaíba River close to the City of Parnaíba in Northern Piauí. Paved roads, BR-343 and PI-210, provide easy access to the project area. Road distances from the project area to Teresina and São Luís do Maranhão are 340 km and 1,290 km, respectively. About 70% of the area is still covered by natural vegetation and 30% cropped under rainfed conditions, but without any basic infrastructure. Mean annual precipitation is around 1,200 mm and concentrated between January and March. Heavy rainfall also occurs in June. Mean monthly temperatures are around 27°C, November and December being the hottest months. Average wind velocities are around 3 m/sec, with average monthly values of 4.5 m/sec between September and November. The Tabuleiros Litorâneos project would pump water from the Parnaíba River. The river has a mean flow of 759 m³/sec and an average minimum daily flow of 246 m³/sec at the diversion site. The lowest flow recorded in 21 years of observation was 207 m³/sec. Project needs, when compared with the above figures are insignificant. The chemical water quality is good (Cl-Si). However, the river carries a great amount of materials in suspension which might increase filtration costs for localized irrigation systems and affect irrigation equipment. The topography of the project area is gently undulating with slopes below 3%. Natural creek crossings would provide adequate surface drainage. Soils are coarse textured, ranging from sands to loamy sands at the surface, underlain by sandy loams. Infiltration rates are high (over 120 mm/h) and moisture holding capacities seldom exceed 6 cm/m.

**Water Demand**

- Water demand has been estimated based on calculated potential evaporation by the Hargreaves method and applying crop factors as recommended in FAO handbook 24. Irrigation efficiencies have been assumed at 90% for conveyance and distribution and 65% for on-farm irrigation. The low on-farm sprinkler irrigation efficiency takes into account prevailing wind conditions. Overall water requirements at the main pumping station during peak demand periods have been estimated at 1.32 l/sec/ha.

**Off-Farm Infrastructure**

- The project would pump water for irrigation of about 8,300 ha, S.A.U. including the 7,510 ha proposed project, from the Parnaíba River by means of a 1.1 km inlet canal and a main pumping station (ZBP). The latter would be equipped with 10 vertical pumps (2 groups of 5 pumps) and lift 13.1
m$^3$/sec 50 m high. Two pressure lines of 1,560 m would discharge the water into a regulating reservoir equipped with control gates to release water into a 25.7 km main canal (CP) according to irrigation demands. Most of the above mentioned headworks have already been constructed and the proposed project would provide only: (a) equipment to complete one group of pumping units (3 pumps of 1.31 m$^3$/sec) and two pressure lines of 1560 m; and (b) civil works and equipment for the second group (5 pumps of 1.31 m$^3$/sec) and 2 pressure lines of 1,560 m. The main conveyance canal has also been completed. The distribution network for the 7,510 ha project area would comprise 25.5 km of canals, pressurization pumping stations (one for an average 500 ha) and pipe network for delivery of metered pressurized water at farmgates.

On-Farm Irrigation Works

11. Medium and large holdings (16ha and 32ha units) would install their own on farm irrigation system and, considering prevailing wind conditions and soil characteristics, are expected to choose micro sprinklers or closely spaced conventional sprinklers. Settlers on 2 to 8 ha lots would be provided with conventional sprinkler systems consisting of a buried main line and three fly lines. Sprinklers would be spaced at 12 x 12m and discharge 1.66 m$^3$/h. Operating pressure would be 25m. During peak demand months the irrigation interval would be every 2 days. The project would also provide wind breaks to increase irrigation efficiencies.

Complementary Physical Infrastructure

12. The project would include the construction of a simple surface water drainage system to evacuate the run-off into natural drains. Land preparation would comprise land clearing, establishment of wind breaks and application of soil amendments. It would also include the construction of 82 km of graveled roads. Electricity would be supplied by CEPISA through an new 69 kv line. The project would provide a 10,000 kva substation with a 69/13.8 kv transformer and 5.4 km of 13.8 kv lines to serve the project pumping stations. It would construct service centers with offices, workshops, storage facilities, equipment and housing for project support staff.
BRAZIL

NATIONAL IRRIGATION PROGRAM

NORTH EAST IRRIGATION I PROJECT

AGRICULTURE PRODUCTION

A. Formoso "H" Irrigation Scheme

Present Land Use and Soils:

1. CODEVASF owns the project land, which is presently covered by thorn bush vegetation. The project area has predominantly medium textured latosols and podzols (70%), sandy soils (20%) and heavy hydromorphic soils (10%). Experience in similar areas suggests that the medium and light textured soils are suitable to grow a variety of crops under irrigation, with periodic applications of manure and fertilizers. The hydromorphic soils are mainly suited for rice production.

Farm Size Distribution and Settlement Phasing

2. The project area would be settled in four occupation models, two for small farmers and two for commercial-size agricultural enterprises. About 80% of the area would be allocated to small farmers and 20% to commercial farmers. The entire project area would be occupied in the fourth year after initiation of construction. After the installation on their land it would take the farmers an additional two years to bring their total farm area under cultivation. Table I summarizes the projected farm size distribution.

Farm Models

3. Four models illustrate conditions of production under the project and were used for financial and economic analysis. Two models (A, B) refer to small farmers where soil preparation and the rice harvest are mechanized and all other operations are done manually; and two (A, B) refer to medium and large farmers where most farm operations are mechanized.

4. Small Farmers. Model A: a total of 6 ha located on hydromorphic soils. At full development (Year 3), 10 ha of rice would be planted annually, giving a cropping intensity of 167%. Hired labour would meet about 42% of the total annual labour requirements, the remainder would be family labour. Model B: Total of 6.3 ha consisting of medium textured soils suitable for growing a wide variety of crops. At full development (Year 4), the planted area would consist of: cotton 4.5 ha, beans 4.5 ha, carrots 0.5 ha, and grapes 0.5 ha. The cropping intensity would be 167% (perennial crops equivalent to two annual crops for estimating cropping intensity). Annual hired labour requirements would be about 45% of total.
5. **Large Farmers. Model A:** Total of 40 ha located on hydromorphic soils. At full development (Year 3), the planted area would consist of 70 ha of rice, giving a cropping intensity of 175%. Most farm operations would be based on hired labour. **Model B:** Total of 45 ha of medium to sandy textured soils. At full development (Year 2), the planted area would consist of: cotton 35 ha, beans 30 ha, onions 4 ha, bananas 3 ha, and passion fruit 3 ha. The cropping intensity would be 180%. Most farm operations would be based on hired labour.

8. **Barreiras Norte Irrigation Scheme**

**Present Land Use and Soils**

6. The project area is presently occupied by about 103 farms of various sizes. About 28% of the farms are larger than 100 ha and occupy 84% of the project area. The medium size farms of between 20 to 100 ha represent 35% of the total farms and occupy 14% of the land, while farms of less than 20 ha represent 37% of the farms and occupy only 2% of the area. Large holding are generally covered by natural vegetation and pastures for extensive beef production. The carrying capacity is low, about 5 ha per head and cattle is sold at 300 kg at about 5 years. Small farmers grow subsistence crops, mainly manioc and maize and beans planted in association to meet family food requirements. About 174 ha are presently cropped with extremely low yields (manioc: 5.0 t/ha; maize: 0.4 t/ha; and beans: 0.2 t/ha).

7. Most soils are deep and medium textured. About 85% are red-yellow podzols and the remaining are alluvial low lands. The soils are well suited for irrigation and capable of producing a wide variety of crops, but require periodic applications of manure and intensive use of fertilizers.

**Farm Size Distribution and Settlement Phasing**

8. The project area would be settled in five occupation models: Farms of net cultivated area of 2 to 4 ha for farmers entitled for resettlement, farms of 7.5 ha for small farmers; farms of 17.5 ha for agricultural technicians, farms of 26 ha for agronomists and farms of 49 ha for commercial enterprises. It is estimated that four years would be required to settle farm operators and their families after project construction is initiated. Table 1 summarizes projected farm size distribution.

9. **Farm Models**

9. Three models illustrate conditions of production under the project. One model represents farmers whose land has been requisitioned, who would have to be settled in the project area, and who would perform all farm operations manually; the second represents small farmers and farms of agricultural technicians where soil preparation is mechanized and all other operations are done manually; and the third refers to farms of agronomists and commercial farmers where most farm operations are mechanized.
10. **Resettlement Farmers. Model A**: Total of 3 ha under cultivation. At full development (Year 3), the planted area would consist of: manioc 1 ha, maize in association with beans 2.5 ha and cotton 1 ha. The cropping intensity would be 150% based on family labour.

11. **Small Farmers. Model A**: Total of 9 ha under cultivation of a wide variety of crops. At full development (Year 4) the planted area would consist of: cotton 3 ha, beans 5 ha, onions 1 ha, bananas 1 ha, papayas 1 ha, and passion fruit 1 ha. The cropping intensity would be 167%. Annual hired labour requirements would be about 52% of total.

12. **Large Farmers. Model A**: Total of 36 ha under cultivation. At full development (Year 7), the planted area would consist of: cotton 12 ha, beans 20 ha, onions 4 ha, tomatoes 4 ha, citrus 6 ha and mangoes 6 ha. The cropping intensity would be 178%.

C. **Acadad Irrigation Scheme**

**Present Land Use and Soils**

13. The project area is presently subdivided into 293 farms. About 78% of the farmers operate units of less than 25 ha and represent about 20% of the project area. About 13% have between 25 ha and 100 ha and the remaining 9% more than 100 ha. Some 45% of the project area is still covered by natural vegetation, 20% are pastures and 35% cropped with manioc (5.0 t/ha) and maize (0.4 t/ha), the latter in association with beans (0.2 t/ha) or planted with cashew (0.2 t/ha).

14. Project area soils are deep and well drained. Surface textures are sandy loams underlain by loamy sands and sandy clay loams. With proper irrigation management, periodic applications of lime and manure and heavy fertilization these soils are capable of producing a wide variety of crops.

**Farm Size Distribution and Settlement Phasing**

15. The project area would be settled in four occupation models: net cultivated area of 2 to 4 ha for farmers entitled to resettlement, 8 ha for small farmers, 16 ha for agricultural technicians, and 80 ha for large commercial farmers. Four years would be required to settle farm operators and their families after project construction is initiated. Table 1 summarizes projected farm size distribution.

**Farm Models**

16. Three models illustrate conditions of production under the project. One model represents farmers whose land has been requisitioned and who would be settled in the project area and who do all farm operations manually; the second represents small farmers and farms of agricultural technicians where only soil preparation is mechanized; while the third model refers to large farmers where most farm operations are mechanized.
17. **Resettlement Farmers. Model A:** Total of 3 ha under cultivation. At full development (Year 3), the planted area would consist of: manioc 1 ha, maize in association with beans 2.5 ha, and cotton 1 ha. The cropping intensity would be 150% based on family labour.

18. **Small Farmers. Model A:** A total of 9 ha under cultivation of a wide variety of crops. At full development (Year 6), the planted areas would consist of: cotton 5 ha, peanuts 1 ha, carrots 1 ha, melons 2 ha, mangoes 1 ha and passion fruit 2 ha. The cropping intensity would be 167%. Annual hired labour requirements would be about 56% of total.

19. **Large Farmers. Model A:** A total of 80 ha under cultivation. At full development (Year 7), the planted area would consist of: cotton 45 ha, beans 25 ha, peanuts 30 ha, tomatoes 10 ha, mangoes 5 ha, grapes 5 ha and passion fruit.

D. **Tabuleiros Russas Irrigation Scheme**

**Present Land Use and Soils**

20. The project area is currently occupied by 434 farmers with farms of different sizes. About 77% of the holdings are below 25 ha in size and represent 18% of the project area, 18% are between 25 and 100 ha and the remaining 5% are farms larger than 100 ha. About 44% of the area is still covered with natural vegetation, 20% covered with pastures and 36% (about 3,700 ha) dedicated to crop production, mainly manioc (5.0 t/ha), maize (0.4 t/ha) associated with beans (0.2 t/ha), cotton (0.4 t/ha) and cashews (0.2 t/ha).

21. Predominant soils are deep and well drained red-yellow podzols with sandy to medium textures. With periodic applications of lime and manure and intensive fertilization, these soils are suitable for production of a wide range of crops under irrigation.

**Farm Size Distribution and Settlement Phasing**

22. The project area would be settled during a five-year period, in seven occupation models, as shown in Table 1.

**Farm Models**

23. Four models illustrate conditions of production under the project: resettlement farmers, small farmers and agricultural technicians, agronomists and small enterprises, medium and large enterprises.

24. **Resettlement Farmers. Model A:** Total of 3 ha under cultivation. At full development (Year 3), the planted area would consist of: manioc 1 ha, maize in association with beans 2.5 ha and cotton 1 ha. The cropping intensity would be 150% based on family labour.

25. **Small Farmers. Model A:** A total of 9 ha would be under cultivation at full development (Year 5) and would consist of: cotton 5 ha, beans 5 ha, carrots 1 ha, grapes 1 ha, and passion fruit 1 ha. The cropping intensity would be 167% based on 56% of hired labour.
26. **Large Farmers. Model A:** With a total of 36 ha under cultivation at full development (Year 4), the planted area would consist of: cotton 14 ha, beans 25 ha, onions 6 ha, tomatoes 4 ha, bananas 4 ha, and grapes 4 ha. The cropping intensity would be 181%. **Model B:** A total of 80 ha under cultivation and at full development (year 7) would consist of: cotton 35 ha, beans 40 ha, onions 6 ha, tomatoes 10 ha, citrus 15 ha, and grapes 10 ha. The cropping intensity would be 176%.

### E. Guadalupe Irrigation Scheme

#### Present Land Use and Soils

27. About 63 families live in the project area, 10 of which are land owners, 32 squatters, 13 share croppers and 8 lease holders. The ownership pattern is skewed with 77% of the owners having less than 10 ha each and 14% between 1,000 ha and 2,000 ha. At present some 200 ha are cultivated at a very low productivity level with subsistence crops (maize and beans in association, manioc) small citrus orchards can be found around the houses.

28. Latosols and podzols dominate in the project area. The soils are deep and well drained. Textures are mainly sandy loams underlain by sandy clay loams. With proper irrigation management, and periodic applications of manure, these soils are adequate for cultivation of a variety crops.

#### Farm Size Distribution and Settlement Phasing

29. The project would be settled in four occupation models: farms of net cultivated area of 2 to 4 ha for resettlement farmers, 8 ha for small farmers, 16 ha for agricultural technicians and agronomists, and 32 ha for large farmers. Five years would be required to settle farm operators and their families after project construction is initiated. Table 1 summarizes projected farm size distribution.

#### Farm Models

30. **Farm Models.** Three models illustrate conditions of production under the project: resettlement farmers, small farmers and agricultural technicians, and agronomists and commercial farmers.

31. **Resettlement Farmers. Model A.** Total of 3 ha under cultivation. At full development (Year 3), the planted area would consist of: manioc 1 ha, maize in association with beans 2.5 ha and cotton 1 ha. The cropping intensity would be 150% based on family labour.

32. **Small Farmers. Model A:** A total of 9 ha under cultivation of a wide variety of crops. At full development (Year 6), the planted areas would consist of: cotton 4 ha, beans 4 ha, peanuts 3 ha, papayas 1 ha, grapes 0.5 ha, and bananas 0.5 ha. The cropping intensity would be 167% based on 38% of hired labour.

33. **Large Farmers. Model A:** A total of 22.5 ha would be under cultivation and at full development (Year 4), would consist of: cotton 6.5 ha, beans 9 ha, onions 3 ha, peanuts 9 ha, bananas 3 ha, and grapes 3 ha. The cropping intensity would be 176%.
F. Tabuleiros Litoraneos Irrigation Scheme

Present Land Use and Soils

34. Most of the project area is privately owned with an average farm size of about 155ha. About 90% of the area is under natural vegetation, meanwhile the remaining 10% are cultivated with subsistence crops, mainly manioc (5 t/ha), maize (0.4 t/ha) associated with beans (0.2 t/ha) and cashew (0.2 t/ha).

35. The project area soils are deep, well drained and very light textured: sandy to loamy sand in the surface horizon and sandy loams to clay loams in the sub-surface. They are extremely low in natural fertility and have a high infiltration rate. Liming, the use of fertilizers and farm manure would be required to maintain crop productivity. The area is suitable for growing high value crops of fruit and vegetables under an effectively managed irrigation scheme.

Farm Size Distribution and Settlement Phasing

36. The project area would be settled in five occupation models: 2 to 4 ha for resettlement farmers, 8 ha for small farmers, 16 ha for agricultural technicians and agronomists, and 32 ha for commercial farm enterprises. Settlement of all producers would be accomplished within four years after start of construction. Table 1 summarizes projected farm size distribution.

Farm Models

37. Three models illustrate conditions of production under the project, resettlement farmers, small farmers and agricultural technicians, and agronomists and large farmers.

38. **Resettlement Farmers** Model A: Total of 3 ha under cultivation, and at full development (Year 3), the planted area would consist of: manioc 1 ha, maize in association with beans 2.5 ha and cotton 1 ha. The cropping intensity would be 150% based on family labour.

40. **Small Farmers** Model A: Total of 9 ha under cultivation, and at full development (Year 3), the planted area would consist of: cotton 6 ha, peanuts 5 ha, and passion fruit 2 ha. The cropping intensity would be 167% based on 58% of hired labour.

41. **Large Farmers** Model A: A total of 22.5 ha under cultivation and at full development (Year 7), would consist of: cotton 12.5 ha, peanuts 10 ha, onions 2 ha, bananas 2 ha, citrus 4 ha and passion fruit 2 ha. The cropping intensity would be 180%.

G. Cropping Patterns, Yields and Production

41. The cropping patterns at full development would include traditional crops (varying from 48% in the Tabuleiros Litaneos scheme to 91% in the Formoso H scheme) such as beans, maize, manioc, cotton and rice, high
value annual crops (varying from 10% in the Barreiros scheme to 36% in the Tabuleiros Litoraneos scheme) such as tomatoes, carrots and peanuts, and high value perennials (varying from 5% in the Tabuleiros scheme to 22% in the Barreiras scheme) such as bananas, grapes, passion fruit, citrus, mangoes and papaya. Double cropping would bring cropping intensities at full development to almost 150 in the case of resettler farmers, 167 for small holders, and about 180 for farm enterprises.

42. Projected crop yields, areas, total annual production at full development are summarized in Table 2. Yield projections assume that small farmers would need three years to achieve maximum levels and commercial enterprises two years. Estimated yield levels are comparable with those obtained in other irrigated areas in the Northeast of Brazil. Yields for annual crops have been estimated higher by 10% for commercial enterprises as compared to small holders, due to mechanization and better management, while the yields of perennial crops were considered the same for all farmers.

Financial Results

43. The financial analysis of the farmers who are expected to participate in the irrigation project has been carried out on the basis of farm models. The main assumptions regarding the financial analysis of the models summarized below:

Input and output prices. The farm gate prices of inputs and crops have been analysed over a period of ten years. The prices are the average of the yearly quotations which were deflated and brought to mid-May 1989 base.

Project life. The life of the project assumed in the analysis is 30 years which corresponds to the average life of the on-farm irrigation equipment.

Replacement of equipment. Replacement of on-farm irrigation equipment has been included and costed in each model according to its useful life.

Cost recovery. It has been assumed that farmers will be able to repay for the investments and O&M costs of the off-farm infrastructure and, in the case of farmers below 9 ha, for the costs of the extension service.

Terms of credit. It has been assumed that farmers will be able to repay for all costs of on-farm improvement and equipment under credit arrangements. Farmers below 10 ha, according to the Irrigation Law, will have to repay their loan obligations over a period of 25 years at an interest rate of 6% p.a. Larger farmers, with more than 10 ha, and commercial enterprises will repay over a period of 12 years at real annual interest rate of 7%.

Opportunity cost of capital. An opportunity cost of capital of 12% has been assumed in the analysis.
The results obtained, on the basis of the above assumptions are summarized below:

The analysis of the models suggests that investments are attractive with financial rates of return varying from a minimum of 22.61 to more than 100%.

Only in the case of the 3.0 ha resettled farmers, the rate of return for the most expensive schemes, as in the case of Acarau, may drop below the opportunity cost of capital.

The sensitivity analysis shows that the models are in general not very sensitive to variations either in costs or in the value of production.

According to the analysis of the cash flow projections farmers will be able to pay water charges, in addition to paying for acquisition of land and improvements made in their farms.

A summary of the financial analysis results is presented in the following table:

<table>
<thead>
<tr>
<th></th>
<th>On-farm Invest.</th>
<th>Water Charges</th>
<th>Net Income After Debt</th>
<th>F.R.R. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formoso &quot;H&quot;</strong></td>
<td></td>
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<td></td>
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<tr>
<td>6 ha Model</td>
<td>5,860</td>
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<td><strong>Tab. Ruses</strong></td>
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<td>16,800</td>
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</tr>
<tr>
<td>36.0 ha</td>
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<td><strong>Tab. Litoraneos</strong></td>
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<tr>
<td>22.5 ha</td>
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<td><strong>Guadalupe</strong></td>
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<td></td>
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<tr>
<td>9.0 ha Model</td>
<td>16,500</td>
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</tr>
<tr>
<td>22.5 ha</td>
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<td>15,400</td>
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<td><strong>Resettled Farmers</strong></td>
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<td>1,500</td>
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</table>
A. SETTLEMENT OF BENEFICIARIES

1. Farmer settlement would include selection of beneficiaries, allocation of farming units, follow-up during a probation period and preparation and delivery of land titles. The executing agencies CODEVASF (Barreiras and Formoso H), DNOCS (Acarau and T. Russas) and DNOS (Guadalupe and T. Litorâneos) would be responsible for all settlement procedures. The project would provide irrigated land for: (a) commercial enterprise or large farms; (b) farmers with technical agricultural background and commercial farming experience; (c) qualified settlers; (d) resettlement farmers; and (e) secondary beneficiaries (para. 5). All beneficiaries, except commercial enterprises and secondary beneficiaries, would have a five year probation period. If they do not perform satisfactorily during this period, they would not receive their land titles and would be removed from the project area. The following table outlines the number of beneficiaries by type and subproject.

### Project Beneficiaries

<table>
<thead>
<tr>
<th>Sub-Project</th>
<th>Commercial Enterprise (24-80 ha)</th>
<th>Medium-Sized Farmers (16-24 ha)</th>
<th>Qualified Small Holders (6 - 8 ha)</th>
<th>Resettlement Farmers (2 - 4 ha)</th>
<th>Secondary Beneficiaries (up to 3 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barreiras</td>
<td>36</td>
<td>137</td>
<td>472</td>
<td>209</td>
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<tr>
<td>Formoso &quot;H&quot;</td>
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<td>-</td>
<td>615</td>
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<td>110</td>
<td>538</td>
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<td><strong>TOTAL</strong></td>
<td><strong>268</strong></td>
<td><strong>589</strong></td>
<td><strong>3,378</strong></td>
<td><strong>982</strong></td>
<td><strong>159</strong></td>
</tr>
</tbody>
</table>
Commercial Enterprise

2. About 270 commercial enterprises or large farmers would acquire 24 ha to 80 ha plots through a competitive bidding process. They would receive water at the farmgate and develop their land, including the on-farm irrigation and drainage system on their own account. They would pay water charges to cover full investment and operation and maintenance costs for off-farm works, including a 3% annual interest rate in real terms on public investments on off-farm infrastructure.

Small Holders and Medium Size Farmers

3. The majority of the beneficiaries would be about 3,380 qualified small holders (6 ha to 8 ha) and 590 medium sized farmers (16 ha to 24 ha). The latter would have a technical agricultural background, preferably agricultural technicians and agronomists with proven experience in commercial farming. Small and medium irrigators would be selected according to agreed criteria that ensure that they would be able to operate their holdings on a commercial basis without subsidies. Main criteria for selection of farmers would be their education and experience in commercial agriculture, preferably irrigated crop production. Small holders would receive their lots fully equipped with on farm infrastructure, including irrigation works and equipment, which they would repay over a period of 25 years at an annual interest rate of 6% in real terms and a grace period of up to 5 years. Medium sized farmers would develop their farms and their irrigation and drainage systems on their own. Both small and medium sized operators would cover their own on-farm operation, maintenance and replacement costs and pay water charges to cover their portion of off-farm operation and maintenance costs and a 3% annual interest rate on capital investment in off-farm irrigation works.

Resettlement Farmers

4. Construction of project works would affect some 1,170 small holder farmers in the project area whose land would be requisitioned. About 190 families who are more advanced technologically, would qualify to receive 8 ha plots under the project (para. 3). Small holders that do not meet the criteria for "qualified farmers" and are not eligible to receive 6 to 8 ha units, would be resettled by the project on 2 to 4 ha fully irrigated plots within the project area. Special attempts were made to locate these lots as close as possible to their present holdings. About 980 families would fall into this category. Resettlement would include acquisition of the family land, provision of the new lot within the irrigation perimeter (in accordance with the regulations of the National Irrigation Law) and the transfer of livestock and family belongings to the settlement area. Resettlement plans would involve a series of routine preparatory steps for each community, including: (a) a communication campaign; (b) an inventory of livestock and belongings to be transferred; (c) ratification of settlement agreements by each family; and (d) arrangements for actual transfer of the families and their belongings. Resettlement farmers would repay their portion of project investment and operation and maintenance costs in the same manner as qualified small holders. Total resettlement cost, including on farm development and the corresponding portion of off-farm project costs, would amount to US$14.7 million, as shown in the following table.
Resettlement and Secondary Beneficiaries - Cost Estimates

<table>
<thead>
<tr>
<th>Sub-Project</th>
<th>Farm Size (ha)</th>
<th>Resettlement Costs</th>
<th>Secondary Beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beneficiaries No.</td>
<td>Cost US$'000</td>
<td>Beneficiaries No.</td>
</tr>
<tr>
<td>Formoso &quot;H&quot;</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barreiras</td>
<td>3.0</td>
<td>209</td>
<td>4,020</td>
</tr>
<tr>
<td>Acarau</td>
<td>2.7</td>
<td>142</td>
<td>1,790</td>
</tr>
<tr>
<td>T. Russas</td>
<td>2.6</td>
<td>428</td>
<td>5,803</td>
</tr>
<tr>
<td>Guadalupe</td>
<td>3.0</td>
<td>47</td>
<td>850</td>
</tr>
<tr>
<td>T. Litoraneos</td>
<td>3.0</td>
<td>156</td>
<td>2,250</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-</td>
<td>982</td>
<td>14,713</td>
</tr>
</tbody>
</table>

Secondary Beneficiaries

5. These comprise: (a) 114 farmers in Russas whose land would be partially requisitioned for project implementation and who would receive without charge, as indemnization, access to energy and sprinkler irrigation kits (pump, main lines, fly lines, sprinklers) to irrigate between 2 ha and 3 ha each, on their remaining land by pumping from the Jaguaribe river; and (b) 45 small holders adjacent to the Acarau project area who would receive access to water from the project, to develop irrigation on some 2-3 ha on their own; they would pay for the full cost of water. Irrigation development costs (Table 3) for secondary beneficiaries have been estimated at US$496,000, as shown in the table above.

B. AGRICULTURAL EXTENSION

6. The irrigation districts would provide agricultural extension for small farmers. Commercial enterprise and farmers with technical agricultural background have their own means of access to improved and new farming technologies. The mix of direct beneficiaries (paras 1 to 4) is expected to minimize public involvement in the dissemination of advanced technologies and the management of the irrigated areas. Agricultural extension would therefore be limited to assistance for small farmers with the objective of familiarizing them with the most appropriate technological packages for irrigated crop production. The irrigation districts would retain specialized consulting firms for this purpose. During the first years of project operation the extension program would emphasize the following main subjects:
a) Irrigation methods and water management practices;

b) Soil fertility, appropriate use of fertilizers and control of pH levels through periodic liming;

c) Land preparation, seeding and planting;

d) Effective weed control and plant protection measures, efficient use of agro-chemicals;

e) Improved harvesting and storage methods;

f) Economics of crop production and farm management for maximum profitability, and

g) Alternate methods for marketing of produce and provision of inputs.

8. Extension activities would be carried out by basic teams of one agricultural technician and one social extensionist. The latter would divide his/her time between the families covered by two agricultural technicians. Extension agents would first develop farm leaders and then use them to demonstrate correct farming and irrigation practices to groups of 15 or 20 farmers. Demonstration plots would be located within the farm leaders' property.

9. Operation and demonstration units would be installed in each irrigation district with the objective of introducing new crop varieties and improved cultural practices. At the same time and reinforcing the units' performance, experimental practices would be implemented on the land of individual farmers in conjunction with the agricultural research stations.

10. Specialized extension firms would be selected on a competitive basis, in accordance with the Bank guidelines for each sub-project. Their proposals should consider: (a) ratio of farmers per extension agent (about 40 during the first two years); (b) training of extension agents prior to their assignments in the field, and (c) that extension staff would be expected to live within the project area (offices and houses would be provided by the district). The firms should also provide a full time coordinator, supervisors and extension workers, all fully equipped to carry out their tasks. The proposals should provide names, qualifications and experience of the coordinator, supervisors and key staff, indicate the number and qualifications of agricultural and social extension agents and clearly specify the organization of the team.

11. Almost 4,100 small farmers would benefit from the extension service component which would cover an irrigated area of about 27,700 ha. The project would only finance the cost of the extension service during the first two years after installation of all farmers on their lots. Thereafter, the irrigation district would continue to provide the services, charging its cost directly to the beneficiaries. The estimated total cost of the extension component financed under the proposed project would amount to about US$2.2 million.
BRAZIL

NATIONAL IRRIGATION PROGRAM

NORTHEAST IRRIGATION I PROJECT

EXECUTING AGENCIES

Special Secretariat for the National Irrigation Program (SEPRONI)

1. In February 1986, the Government consolidated most federal irrigation functions within the Office of the President, under the direction of a Special Minister of Irrigation (without portfolio). The Minister was charged with drafting the policy and organizational framework for accelerated private sector development, rationalizing the activities of the public sector agencies, (CODEVASF, DNOCS and DNOS), particularly in the Northeast, and securing financial and political support for an integrated national irrigation development effort. Shortly after his appointment, the Minister created two regional coordinating programs: the Northeast Irrigation Program (PROINE) and the National Irrigation Program (PRONI), which was responsible for irrigation development in the remainder of the country. The Minister's plan was to increase total irrigated area in Brazil by 3 million ha, or 120%, over five years (1986-90) -- 400,000 ha of public and 600,000 ha of private irrigation in the Northeast, and 2.0 million ha of private irrigation in the rest of the country. These targets have been scaled back over the past two years due to a growing understanding of the technical and institutional constraints of such an ambitious program, and the dampened economic environment within the country. In December 1988, the Minister of Irrigation incorporated PROINE within PRONI.

2. In January 1989, the Government, as part of its "Summer Plan", abolished the post of the Special Minister of Irrigation. An Executive Secretariat for the National Irrigation Program (SEPRONI) was subsequently established in the Ministry of Agriculture. The PRONI program, together with its three implementing agencies, (DNOCS, DNOS and CODEVASF) were placed under the supervision of the new secretariat. These new arrangements are basically intended as transitional in nature until a more permanent institutional framework for promoting water and irrigation development for the next decade has been defined.

3. SEPRONI is required by the irrigation legislation to prepare the National Irrigation Plan; elaborate rules and regulations related to water use for irrigation; approve regional or local irrigation programs; prepare and sign agreements with public and private institutions and with international organizations in order to achieve the aims of the National Irrigation Plan; establish criteria for the planning, execution, operation, control and evaluation of irrigation projects; and establish norms and procedures for introduction and collection of water charges.
4. In Brasilia, SEPRONI has PRONI, which is responsible for planning and coordination of the subsector. SEPRONI also coordinates MINAGRI agencies with executing responsibilities for public irrigation programs, and liaises with the states with regard to private and public irrigation. For the coordination of preparation activities related to the project, SEPRONI had a four-man special group which remained an informal structure. The formal establishment of the Project Coordination Unit, and the nomination of a Coordinator acceptable to the Bank were conditions for negotiations. These are now in place.

São Francisco Valley Development Company (CODEVASF)

5. CODEVASF's origin dates back to 1948 when the Government established a commission, CVSF, to promote settlement and economic development of the 630,000 km² river basin. The CVSF was modeled on the Tennessee Valley Authority in the US. Its achievements were disappointing, and in 1967, the Government decided to create a Superintendência do Vale do São Francisco (SUVALE) under MINTER, with specific responsibilities for coordination and control of rational use of the water resources of the valley and promotion of economic achievement; promotion of investment opportunities in agro-industrial crop production and in livestock; identification of new development opportunities in the rural sector; and planning and quantification of the services and works required for efficient regulation of the main river and its tributaries. In 1971, the MINTER irrigation group, GEIDA, elaborated the first irrigation targets for the Northeast in the form of the Plano Pluriannual de Irrigação (Multi-year Irrigation Plan - PPI). The first PPI provided the framework for subsequent irrigation activities and stimulated the preparation of various master plans and irrigation projects and led to the creation of CODEVASF in its present form in 1972.

6. CODEVASF is a public sector commercial enterprise. It has a board of directors representing SEPLAN, MINTER, the Ministry of Transport and the Ministry of Mines and Energy, as well as four members appointed by MINAGRI, currently its parent organization. CODEVASF has more freedom than the other Executing Agencies in establishing salaries, and can borrow money and participate in business enterprises such as agroindustries. Its headquarters are in Brasilia and it has five semi-autonomous Regional Directorates located at Montes Claros (Minas Gerais), Salvador (Bahia), Petrolina (Pernambuco), Aracajú ( Sergipe) and Penedo (Alagoas). Regional Directors report to the President, who is supported in Brasilia by four headquarters in the areas of planning and coordination, directorate, engineering, operation and production, and administration and finance.

7. CODEVASF Regional Directors have a considerable degree of autonomy. Within their respective areas, they are responsible for expanding, operating and maintaining CODEVASF irrigated perimeters; supervising the construction of civil works commissioned by CODEVASF; and encouraging the establishment of agroindustries; and providing general support and assistance to other regional or state entities, whether public or private. Regional Directorates have four divisions: programming and execution of civil works, which is also responsible for collecting climatic and hydrological data and promoting improved water use efficiency and soil conservation; operation and maintenance; production support and rural
development; and administration and finance. At the local level, there are an increasing number of irrigation districts in individual projects each with their management and support services team, as well as a variety of special CODEVASF units and support groups.

8. CODEVASF is a well-established organization with generally adequately equipped offices at the local, regional and central levels. It has a total of 950 technical and professional staff, including 152 agriculturalists 110 civil engineers, and 58 economists. Technical studies and civil works are mainly contracted and only minor works are carried out by force account. At present, CODEVASF operates 18 irrigation projects, with some 54,900 ha under cultivation and 15,500 ha in different stages of construction.

National Department of Anti-Drought Works (DNOCS)

9. Problems in implementing the public works program recommended following the drought of 1877-80 led to the establishment of an Inspectorate of Anti-Drought Works (IOCS) in 1909 under the Ministry of Public Works. IOCS became a Federal inspectorate (IFOCS) in 1919. In 1945, it achieved the status of a government department, and under the name, DNOCS was transferred to MINTER. Today, DNOCS is linked to MINAGRI and operates throughout the semi-arid Northeast, except as an irrigation agency in the São Francisco Valley. Earlier, DNOCS and its predecessors were almost the only public works agencies operating in the Northeast and constructed much of the existing public infrastructure by force account, as well as storage reservoirs, wells, drainage works, and, more recently, public irrigation systems.

10. The current activities of DNOCS are water resource and hydrological studies; preparation of projects and design for civil works to conserve and use water; supervision of construction of these works by contractors; elaboration of plans for integrated development of irrigation and rainfed land (outside of the São Francisco Valley); provision of extension advice on the conservation, development and rational use of water resources; promotion of inland fishery development; and agricultural development of the public irrigation perimeters under DNOCS' responsibility, the last in cooperation with agricultural credit, extension, research and other production and social support agencies.

11. DNOCS headquarters are in Fortaleza, and the organization is divided into four semi-autonomous Regional Directorates (Fortaleza, Teresina, Recife, Salvador). DNOCS headquarters is divided into main departments covering planning and coordination, administration, and operations. Each is under an assistant director general. Within operations, there are directorates covering the areas of studies, irrigation, civil works, rural engineering and fisheries. The regional directors report directly to the director general and are responsible for execution of all DNOCS studies and planning in their areas, and overseeing the construction, operation and maintenance of all local DNOCS facilities and services. Under them are management units which operate the individual irrigation projects and operational nuclei.
12. DNOCS staffing peaked at 18,000 in 1965, at a time when major works were constructed by force account. Staff recruitment was frozen in 1974 and permanent staff had fallen to 5,600 by 1989, of whom about 17% are high level professionals (including about 259 agronomists, 220 civil engineers and 101 economists). The average age of professional staff is 49. Given this age profile, professional staff have a large pool of accumulated experience, but may be somewhat resistant to rapid changes in policies, organization, and functions.

13. Up to 1989, DNOCS and its predecessors had constructed six large public reservoirs with a storage capacity of 8.7 billion cubic meters, plus 285 medium reservoirs, with a capacity of 6.6 billion cubic meters plus 700 small size reservoirs with an additional capacity of about 1.5 billion cubic meters. Only a small part of the water stored in DNOCS reservoirs is currently used for irrigation. At present, DNOCS has 23 irrigation projects in operation with some 21,030 hectares being cropped and 8,300 hectares in various stages of construction but not yet being cropped. A total of 112,000 hectares has been expropriated by DNOCS for agricultural development.

14. DNOCS performance in terms of achievement and managerial development has been poor. There are many causes which have possibly contributed to this poor performance, including under utilization of capacity, excess of personnel and deficient quality services. The most important cause, however, is the lack of definition of objectives; without these results can not be measured against expectations, while deficiencies can easily be attributed to DNOS involvement in different sectors. For many years DNOCS was expected to contribute to broader goals and government policy, with perverse consequences. It was used for expanding employment, resulting in overstaffing which tended to lower morale at the same time, limiting its capability to apply its financial resources to new investments. Nevertheless, the new administration, headed by a competent official well known to the Bank, is making important efforts to clarify objectives and aiming to establish a clear operating framework. It is also committed to implementing DNOCS programs, being aware that subsequent monitoring of results is essential to success.

National Department of Sanitation (DNOS)

15. DNOS is the department of the Ministry of Agriculture responsible for the planning and design, construction and operation of hydraulic infrastructure in Brazil, outside the areas in the Northeast covered by CODEVASF AND DNOCS. Within the Northeast, DNOS only acts if its specific expertise is required by the Ministry of Agriculture. DNOS was also responsible for basic surveys and studies related to possible transfer of water between river basins, such as from the São Francisco Valley to fertile soils in other basins in the northeast part of the region. Projects of this sort are expected to be large, slowly maturing and concern the long-term overall use of water resources.

16. The DNOS is divided in 15 semi-autonomous Regional Directorates, 4 of which are within the northeast region (São Luís, Fortaleza, Recife and Salvador). At headquarters, in Rio de Janeiro, DNOS is divided into six departments covering planning, special programs, irrigation, studies, works
and financing. These departments have a planning, coordinating and control function. The executive functions are a responsibility of the regional directorates that report directly to the director general. DNOS has a total of 2,300 technical and professional staff including civil engineers, economists and financial analysts. Technical studies and construction of civil engineering works are contracted to private firms.

17. DNOS is a well-established construction agency and its past experience includes the construction, operation and maintenance, and overall management of semi-public irrigation schemes (covering an irrigated area of about 14,300 ha) in the southern region of the country. Currently, DNOS is working on the implementation of five irrigation schemes, consisting a net area of about 7,900 ha in the States of Maranhão and Piauí, including the construction of pilot irrigated areas in the Guadalupe and Tabuleiros Litorâneos irrigation schemes under the project. In these areas, CODEVASF has assumed, temporarily, the responsibility for the organization of water users associations and the coordination of the provision of production support services to the farmers.
## ANNEX VII

### NATIONAL IRRIGATION PROGRAM

#### WESTERN IRRIGATION PROJECT

#### PROJECT COST BREAKDOWN AND PROJECT COMPONENTS BY YEAR

(US MILLION)

<table>
<thead>
<tr>
<th>Estimated Project Costs</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Local</td>
<td>Foreign</td>
</tr>
</tbody>
</table>

### A. Construction of Small Irrigation Schemes

<table>
<thead>
<tr>
<th></th>
<th>Local</th>
<th>Foreign</th>
<th>Total</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Farm Irrigation and Drainage Infrastructure</td>
<td>159.2</td>
<td>51.4</td>
<td>204.6</td>
<td>62.8</td>
<td>64.1</td>
<td>22.8</td>
</tr>
<tr>
<td>On-Farm Irrigation and Drainage Infrastructure</td>
<td>69.3</td>
<td>20.9</td>
<td>90.2</td>
<td>13.7</td>
<td>30.4</td>
<td>31.2</td>
</tr>
<tr>
<td>Electrical Networks</td>
<td>9.2</td>
<td>4.8</td>
<td>14.0</td>
<td>6.5</td>
<td>4.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Road Systems</td>
<td>7.8</td>
<td>1.4</td>
<td>9.2</td>
<td>2.8</td>
<td>3.1</td>
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<tr>
<td>Administrative Buildings</td>
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<td>3.1</td>
<td>1.3</td>
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<tr>
<td>Irrigation Adjacent Small Holders</td>
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<td>0.1</td>
<td>0.7</td>
<td>-</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Sub-Total**

|                                |       |         |       |       |       |       | 241.4 | 67.4  | 309.2 | 66.8  | 112.0 | 59.8  | 29.7  | 10.4  |

### B. Initial Operation of the Irrigation Activities

|                                |       |         |       |       |       |       |       | 22.3  | 4.3   | 26.6  | 0.7   | 5.1   | 6.9   | 7.6   | 4.3   |
|                                |       |         |       |       |       |       |       |       |       |       |       |       |       |       |       |

### C. Technical Assistance and Consultant Services

|                                |       |         |       |       |       |       |       | 24.2  | 12.8  | 37.0  | 10.0  | 11.7  | 9.9   | 3.8   | 1.6   |
|                                |       |         |       |       |       |       |       |       |       |       |       |       |       |       |       |

**TOTAL**

|                                |       |         |       |       |       |       |       | 288.4 | 104.5 | 392.9 | 99.2  | 128.8 | 107.4 | 41.1  | 16.3  |       |
|                                |       |         |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

### D. Other Costs

|                                |       |         |       |       |       |       |       | 22.2  | 6.0   | 28.2  | 7.2   | 9.4   | 8.6   | 3.8   | 1.2   |
|                                |       |         |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|                                |       |         |       |       |       |       |       | 31.0  | 11.0  | 42.0  | 8.9   | 9.9   | 18.0  | 8.3   | 3.9   |       |
|                                |       |         |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| **TOTAL**                      | 341.4 | 123.5   | 464.9 | 110.3 | 148.1 | 132.0 | 53.2  | 21.4  |       |       |       |       |       |       |       |       |
## ANNEX VIII

Table 1

### BRAZIL

**NATIONAL IRRIGATION PROGRAM**

**NORTHEAST IRRIGATION I PROJECT**

### ESTIMATED SCHEDULE OF BANK DISBURSEMENTS (US$ Million)

<table>
<thead>
<tr>
<th>Bank Fiscal Year</th>
<th>Quarter Ending</th>
<th>Disbursed During Quarter</th>
<th>Cumulative Disbursement Amount</th>
<th>% of Total of Loan</th>
<th>Balance of Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>Mar 31, 1990</td>
<td>0.0</td>
<td>-</td>
<td>0</td>
<td>210.0</td>
</tr>
<tr>
<td></td>
<td>Jun 30, 1990</td>
<td>7.8</td>
<td>7.8</td>
<td>4</td>
<td>202.2</td>
</tr>
<tr>
<td>1991</td>
<td>Sep 30, 1990</td>
<td>17.5</td>
<td>12</td>
<td>184.7</td>
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</tr>
<tr>
<td></td>
<td>Dec 31, 1990</td>
<td>13.5</td>
<td>18</td>
<td>171.2</td>
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<td></td>
<td>Jun 30, 1991</td>
<td>14.5</td>
<td>66.8</td>
<td>32</td>
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</tr>
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<td></td>
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<td></td>
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<td>46</td>
<td>112.5</td>
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<tr>
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<td>Jun 30, 1992</td>
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<td>70</td>
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<tr>
<td></td>
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<td>9.3</td>
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<td>16.9</td>
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<td>6.9</td>
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<tr>
<td></td>
<td>Jun 30, 1994</td>
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<td>1995</td>
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</tr>
</tbody>
</table>
ECONOMIC ANALYSIS AND SENSITIVITY TESTS

1. Economic rates of return have been estimated for the project as a whole and for the six irrigation schemes. The incremental production of each scheme, resulting from irrigated land that previously sustained almost no economic activity is the main quantifiable benefit of the project. This has been calculated on the basis of the incremental production of the farm models. (Annex IV)

2. The main assumptions underlying the analysis are:

(a) **Project life.** Thirty years, based on the economic life of the irrigation infrastructure.

(b) **Without project situation.** Only 7,770 ha, or about 16% of the total project area are presently cultivated. Farmers mostly grow subsistence crops such as manioc, maize and beans, and they also produce some cash crops such as cashew and cotton. However insignificant for the results of the analysis, an attempt has been made to quantify the existing production and its value has been allowed for in the calculation of the economic rate of return.

(c) **Project costs.** The costs stream includes all capital and recurrent costs such as irrigation and drainage infrastructure, roads, O&M, equipment and consultancy services. Taxes, which amount to 10.3% on civil works and 27% on equipment, and other transfer payments such as the purchase of land have been excluded from the project's cost stream. Physical contingencies at 5% for Formoso, Barreiras and Acaráu; and 10% for Russas, Tabuleiros Litorâneos and Guadalupe have been added to costs.

(d) **Replacement of equipment.** Replacement of equipment has been included in the analysis according to the following schedule:

- on-farm irrigation equipment every 6 years;
- canal equipment, pumping and pressurization stations, 15 years;
- pipes, power lines and others 30 years.

(e) **Prices of commodities.** All prices have been expressed in constant 1989 currency units. Boarder prices of cotton, rice, maize and citrus, internationally traded commodities, have been derived on
the basis of the World Bank price projections of 1988. All other prices are farmgate prices.

(f) **Exchange rate.** The shadow exchange rate has been estimated to be approximately 24% higher than the official rate in 1988. In 1989 the local currency was initially substantially devalued and then held constant for several months and then permitted the rise again. In view of this, a shadow exchange rate 25% higher than the official rate was chosen for 1989. This results from a shadow exchange rate of US$1.00 = NCZ$ 1.40.

(g) **Cost of fertilizers.** Brazilian fertilizer prices are generally in line with the quotations of the international markets. However an adjustment has been introduced to account for the existing distortion of the country's exchange rate which is affecting the value of imported fertilizers. These account for about 50% of total national consumption. The adjustment consisted of multiplying fertilizer prices by a conversion factor of 91%, which has been obtained by applying the exchange rate conversion factor, 83% to 50% of fertilizer prices.

(h) **Wage rate.** The employment situation and labor opportunities in each irrigation scheme have been analyzed in a study by the Getulio Vargas Foundation. Based on this study the following conversion factors have been adopted to estimate the project's opportunity cost of labor: Formoso H and Barreiras, 70%; Acarau, Tabuleiros Litorâneos and Russas, 60%; and Guadalupe, 50%.

(i) **Prices of energy.** The cost of electrical energy in Brazil is subsidized at a rate of 34%, according to studies by the USBR (United States Bureau of Reclamation) and the Getulio Vargas Foundation. For this reason, energy tariffs have been adjusted in the analysis from US$0.038/KWH to US$0.051/KWH.

(j) **Other costs.** All other costs of production inputs such as seeds, seedlings and machinery have been considered as internationally non-traded commodities and valued at their financial prices.

3. The total incremental production of the project (Annex IV) would reach, from Year 10 onwards, approximately: 62,800 tons of cotton, 59,000 tons of passion fruit, 46,800 tons of citrus, 55,000 tons of tomatoes, 18,000 tons of banana, 51,000 tons of grapes, 48,000 tons of onions, in addition to other traditional crops such as 38,000 tons of beans, 20,000 tons of peanuts, and smaller quantities of rice, maize and manioc.

4. The economic rates of return (Table 1), based on the above assumptions, show that the proposed investments in irrigation in the six perimeters are economically viable.
<table>
<thead>
<tr>
<th>Irrigation Scheme</th>
<th>Economic Rate of Return (X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formoso</td>
<td>16.7</td>
</tr>
<tr>
<td>Tabuleiros de Russas</td>
<td>18.5</td>
</tr>
<tr>
<td>Tabuleiros Litorâneos</td>
<td>14.2</td>
</tr>
<tr>
<td>Guadalupe</td>
<td>14.5</td>
</tr>
<tr>
<td>Acarau</td>
<td>17.1</td>
</tr>
<tr>
<td>Barreiras</td>
<td>14.2</td>
</tr>
<tr>
<td><strong>Total Project</strong></td>
<td><strong>16.0</strong></td>
</tr>
</tbody>
</table>

5. The above conclusions are confirmed by the results of the switching values of the overall project detailed in Table 2. The economic rate of return appears moderately more sensitive to reductions in the value of production than to increases in costs; when the value of production decreases by 14%, or costs increase by 19%, the ERR becomes equal to the assumed opportunity cost of capital of 12%. The sensitivity analysis of each individual project, however, shows that three projects, Tabuleiros Litorâneos, Guadalupe and Barreiras, are very sensitive to variations in the value of production; there, a decrease of the value of production by about 8% generates an ERR of 12%.
BRAZIL

NATIONAL IRRIGATION PROGRAM

NORtheast IRRIGATION PROJECT

DOCUMENTS AVAILABLE IN PROJECT FILES

A. Documents prepared by PRONT

1. General Report
2. Project Management
   Annex A: Institutional Framework
   Annex B: Institutional Regulations
   Annex C: Training Program
3. Irrigation Districts Organization
4. Production and Marketing
   Annex A: Potential Markets for Agricultural Products
   Annex B: Marketing Structure
5. Resettlement Program
6. Environmental Impact
7. Monitoring and Evaluation System
8. Technical Assistance to DNOCS
9. Laws and Regulations
10. Formoso H Irrigation Sub-Project: Summary
11. Barreiras Norte Irrigation Sub-Project: Summary
12. Acarau Irrigation Sub-Project: Summary
13. Russas Irrigation Sub-Project: Summary
14. Guadalupe Irrigation Sub-Project: Summary
15. Tabuleiros Litorâneos Irrigation Sub-Project: Summary

B. Documents Prepared by the Executing Agencies and their Consultants

1. Formoso H Irrigation Sub-Project: Feasibility Report
2. Barreiras Norte Irrigation Sub-Project: Feasibility Report
3. Acarau Irrigation Sub-Project: Feasibility Report
4. Russas Irrigation Sub-Project: Feasibility Report
5. Guadalupe Irrigation Sub-Project: Feasibility Report

C. Other Documents

1. Agreements entered into by project participating entities.
2. Report on taxes exemption for goods and equipment.