GOVERNMENT OF THE REPUBLIC OF HONDURAS
MINISTRY OF NATURAL RESOURCES

CHOLUTECA RIVER BASIN AGRICULTURAL DEVELOPMENT PROJECT

UPDATING FEASIBILITY STUDY

VOLUME I

MAIN REPORT

FEBRUARY 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

REPORT

Volume - I	MAIN REPORT	(English & Spanish)
Volume - II	ANNEXES	(English)
Annex A	General Background	
Annex B	Sectoral Background	
Annex C	Meteorology and Hydrology	
Annex D	Geology and Soils	
Annex E	Present Situation of Agriculture	
Annex F	Proposed Agriculture	
Volume - III	ANNEXES	(English)
Annex G	Alternative Plans	
Annex H	Irrigation and Drainage Plan	
Annex I	Dam and Power Plan	
Annex J	Project Evaluation	

PREFACE

In response to the request of the Government of the Republic of Honduras, the Government of Japan decided to conduct an updating feasibility study on the Choluteca River Basin Agricultural Development Project and entrusted the study to Japan International Cooperation Agency. The J.I.C.A. sent to Honduras a survey team headed by Mr. T. Otani from August to September, 1984.

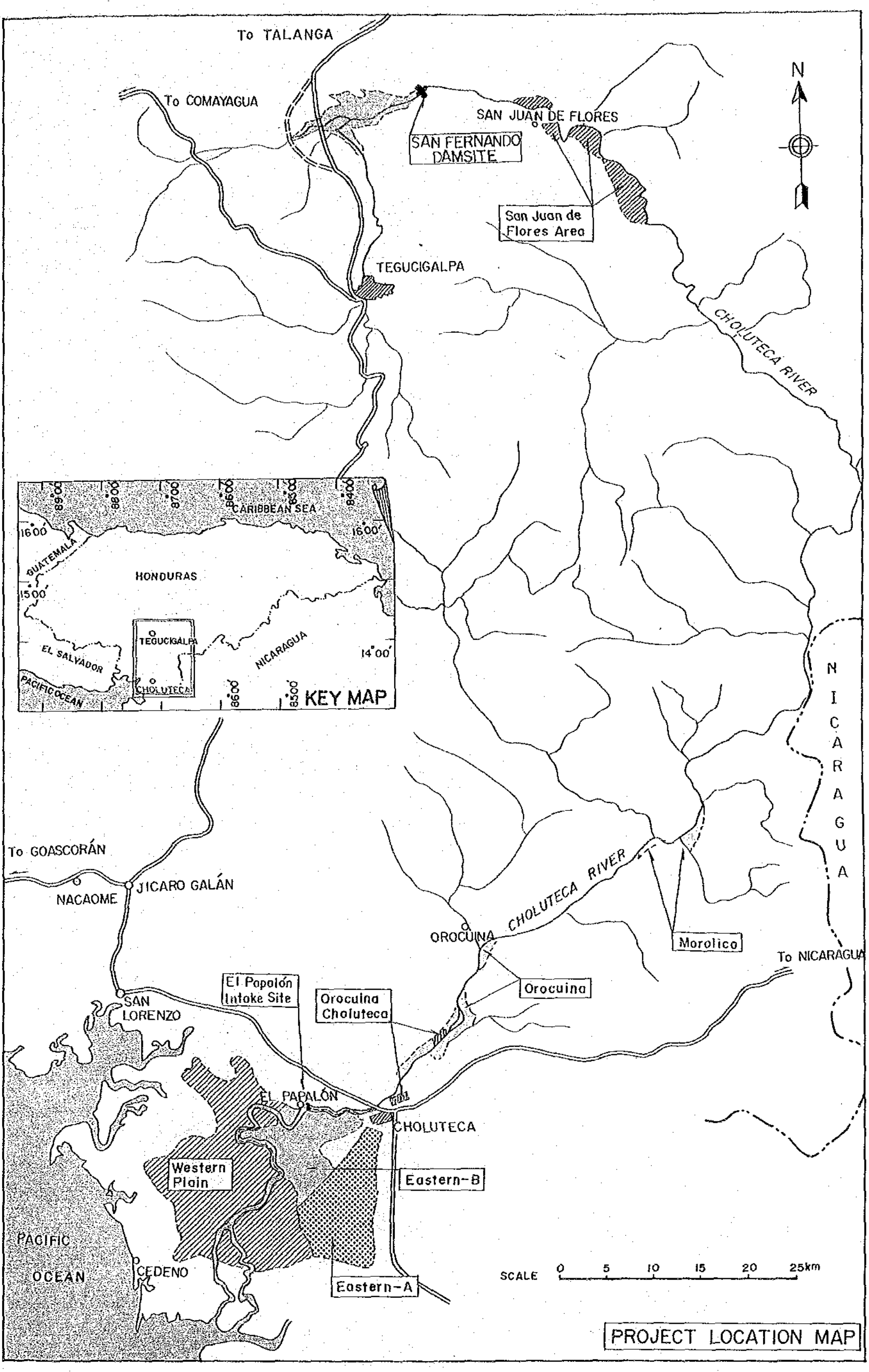
The team exchanged views on the Project with the officials concerned of the Government of the Republic of Honduras and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Honduras for their close cooperation extended to the team.

February, 1985

Keisuke Arita
President
Japan International
Cooperation Agency



PROJECT LOCATION MAP

SUMMARY

Background

01 Despite favorable economic growth achieved in the late 1970's, the economy of Honduras has experienced a recession with negative growth in GDP since 1981. Unemployment and under-employment has increased, and it is necessary to reactivate economic activities in both private and public sectors. Agriculture, which employs about 53% of the economically active population and contributes 25% of the GDP, is recognized as the most important sector for economic and social development of the country. Agricultural production, which provides about 60% of total commodity exports of Honduras, is to be increased to further promote exports and to restore the balance of payment, as well as to feed the rapidly growing population which will reach nearly 5 million in 1990.

02 Agricultural land in Honduras is severely limited, particularly flat land suitable for modernized farming practices. The Choluteca plain is one of the few available flat lands in the country, having sizable areas with fertile to moderately fertile soils. However, the land in the Choluteca plain remains less developed, due primarily to uneven distribution of rainfall. About 93% of the annual rainfall is concentrated in the rainy season, and a long dry season lasts from November to April. Agriculture in the Choluteca plain is therefore at the mercy of climatic conditions under present conditions.

03 To overcome this climatic constraint, it is necessary to introduce irrigated agriculture to the Choluteca plain. With irrigation, agricultural production and productivity will be increased and stabilized. Year round cultivation is practicable, and employment opportunities will be greately expanded. Eventually, it will bring farmers a higher and more stable income, and will contribute to rural development and better balanced regional development in the country. Fortunately, water for irrigation can be made available in the Choluteca river which flows through the central part of the plain. Consequently, agricultural development in the Choluteca plain should be formulated to make the utmost use of water available in the Choluteca river.

Water Resources

04 Water supplies from the Choluteca river are not unlimited. The river discharge decreases substantially in the dry season. To secure water for irrigation, therefore, it is required to construct a dam and reservoir for seasonal regulation of discharge. After a study of alternative storage sites, construction of a dam at San Fernando is

recommended. At the San Fernando damsite, it will be possible to store up to around 400 million cubic meters (MCM). Water stored in the reservoir would be released for irrigation on the Choluteca plain, as well as in the irrigable areas of the middle reach valleys.

05 Through study of reservoir operation at the San Fernando damsite, it has been determined that water can be secured for irrigation of 23,960 ha. It is envisaged that this would be on the Western plain (16,000 ha) and the Eastern plain-A (4,600 ha), in addition to the existing small scale irrigation areas of the middle reach valleys (3,360 ha). However, irrigation in the Eastern plain-B (5,200 ha) can not be secured by any further development at the San Fernando damsite.

Proposed Agriculture

06 Irrigated agriculture on the Choluteca plain could eventually cover the Western plain (16,000 ha) and Eastern plain-A (4,600 ha). Crops to be cultivated in the proposed areas have been selected and their cropping patterns have been elaborated, in accordance with the national policy for agricultural development and adaptability to local climatic and soil conditions, as well as productivity and profitableness under irrigated conditions, marketability of products and familiarity to local farmers. The main crops selected for cultivation are sugar cane, cotton, paddy, maize, beans, sesame, melon, water melon and other horticultural crops, and pasture for livestock breeding.

07 Cultivation of sugar cane is planned to meet the requirements of two existing sugar mills in the Choluteca plain. Production of cotton will be expanded, in view of the favorable climatic conditions in the area. Cultivation of maize is planned to meet the regional demand, and paddy is proposed to satisfy the potential demand which is considered to be relatively high in the country. Production of sesame and melon would also be increased, in view of their favorable and assured markets for export. The proposed cropping area will be around 24,900 ha in the Western plain (crop intensity of about 1.6) and 9,200 ha in the Eastern plain-A. The net agricultural return will be increased from Lp. 17.8 million at market price under the "without" project condition to Lp. 49.5 million in total "with" the proposed project.

08 Water requirements for the proposed irrigation were estimated to be around 288 MCM for the Western plain and 87 MCM for the Eastern plain-A. Water for the San Juan de Flores area (28 MCM) and the existing irrigation areas of the middle reach valleys (22 MCM) will also be secured by the San Fernando reservoir and natural flow from the remaining basin. Irrigation water is mainly required during the dry season, but supplementary irrigation would also be required during the rainy season, including the "canicula" period.

Proposed Facilities

09 A dam and reservoir are proposed for construction at San Fernando, located at about 20 km to the north to Tegucigalpa. From the reservoir operation study, the San Fernando dam is proposed to secure an effective storage capacity of 380 MCM. To this end, it is preliminarily designed to construct a concrete gravity type dam of 100 m in height. The concrete volume would be approximately 472,000 m^3.

10 An intake weir for irrigation on the Western plain would be located near El Papalon, about 9 km downstream from Choluteca. It would be an ogee crested concrete type weir with a floating foundation. The weir would be 4.8 m in height, 140 m in crest length and 15,000 m^3 in volume. The irrigation systems on the Western plain would consist of about 24 km of main canals, 45 km of branch canals, 34 km of secondary canals and 152 km of tertiary canals. The drainage systems would be developed to make the maximum use of old river courses and existing depressions. There would be 90 km of main drainage canals and 27 km of secondary drains. For development of the Eastern plain-A, 7 km of main canals, 30 km of secondary canals, 51 km of tertiary canals, as well as 23 km of main drain and 51 km of collector drain would be constructed in total.

11 At the San Fernando dam, water released for irrigation would be utilizable for power generation by making use of the available head. The generated power would supplement the energy supply, particularly in the dry season. In view of the power demand forecast towards 1990, it is proposed to install power plants at the San Fernando dam. From the reservoir operation study, it is expected that they would generate about 54 GWh of annual energy, with the installed capacity of 18.2 MW. The power generation, however, would be primarily in the dry season when water is released for irrigation, and the generating capacity in November-April will average around 11.1 MW.

Implementation

12 A stage-wise and phased implementation of the proposed facilities will be desirable. It is envisaged that construction of the San Fernando dam at the full scale with irrigation of 16,000 ha on the Western plain would be implemented in the first stage. Expansion of the irrigation systems to the Eastern plain-A is envisaged in the second stage. If initial investment in the first stage has to be decreased, it would be possible to split this into phase 1-1 for irrigation of 12,400 ha on the right bank of the Choluteca river and phase 1-2 for irrigation of 3,600 ha on the left bank of the river.

13 It is recommended that detailed design should be initiated as soon as possible after this updating feasibility study, or in early 1985. If design work is started then, construction of the San Fernando dam could be completed towards the end of 1990. Construction of irrigation and drainage facilities on the Western plain would be executed block by block, the first block being completed by the end of 1988 and the second block by the beginning of 1990. The irrigation block under phase 1-2 would possibly be scheduled for completion by the end of 1990-91 dry season. Implementation of the second stage irrigation development in the Eastern plain - A is provisionally scheduled to start in the middle of 1991.

Construction Cost

14 The cost of the first stage development (dam and irrigation of 16,000 ha) would be around Lp. 302.8 million (US$151.4 million). This initial investment could be reduced to Lp. 272.8 million (US$136.4 million) for construction of phase 1-1 program (dam and irrigation of 12,400 ha), which would comprise Lp. 197.2 million (US$98.6 million) in foreign currency and Lp. 75.6 million (US$37.8 million) in local currency. Disbursement would be made over 7 years in accordance with progress in construction. For implementation of the second stage irrigation development in the Eastern plain - A, an additional investment of Lp. 66.7 million would be required.

Evaluation

15 Implementation of the proposed project has been evaluated in terms of economic internal rate of return (EIRR). The EIRR of the proposed project (first and second stage) was calculated to be 14.2%. This implies that the proposed project is economically feasible. The EIRR of the first stage development (16,000 ha) was also calculated to be 13.7%, and its economic feasibility is evaluated to be justifiable. Even if phase 1-1 is implemented for the time being, the EIRR would be 12.9%. This is still over the least opportunity cost of capital in Honduras.

16 The financial viability of the proposed project has been evaluated in terms of capacity-to-pay and the financial internal rate of return (FIRR). The capacity-to-pay water charges or operation and maintenance cost of irrigation facilities is sufficiently large, because of substantial increase in net revenue per farmer. Such a cost represents only 5 - 12% of the net revenue "with" the project. The FIRR of the installation of power plant and related facilities is as high as 34%. Combined with the dam and irrigation facilities, the FIRR of the integrated first stage development project was estimated to be 13.5%.

17 Unquantified benefits and socio-economic impacts of the project are enormous. Storage in the San Fernando reservoir may be utilized for water supply to the metropolitan area, if technically justified by further study, and the reservoir will attenuate a probable maximum flood downstream. The construction work would create employment opportunities for nearly 4,000 man-years, and the agricultural development in the Choluteca plain would create year round employment for around 13,000 man-years. Resettlement could be promoted in the Choluteca plain for nearly 2,400 additional families. Further, the increase in exports of agricultural products would amount to about US$26.4 million annually and import substitution or foreign exchange saving would amount to about US$14.5 million. The proposed project would eventually serve as a model for further agricultural development in Honduras.

Recommendation

18 The proposed project is evaluated to be technically sound, economically feasible and financially justifiable. It is recommended that the project be implemented stage by stage. To this end, it is recommended that detailed design of the project be initiated at the earliest possible date. Recommendations are also made on various aspects of project implementation, including expansion of the watershed management program, as noted in Chapter XIII of this Main Report.

PRINCIPAL FEATURES

San Fernando Dam

Reservoir:

Catchment area	1,665 km^2
Annual inflow	400 MCM
Active storage capacity	380 MCM
High water level	EL. 826.5 m
Low water level	EL. 797.0 m

Dam:

Type	Concrete gravity
Crest elevation	EL. 835.0 m
Height	100.0 m
Crest length	320.0 m
Volume	472,000 m^3
Spillway capacity	3,380 m^3/s

Choluteca Plain Irrigation Systems

Net Irrigation Area:

Western plain	16,000 ha
Eastern plain - A	4,600 ha
Total	20,600 ha

Intake Weir (El Papalon):

Type	Ogee crest concrete
Height	4.8 m
Length	140 m
Volume	15,000 m^3

Canals in Western Plain:

Main irrigation canals	23.6 km
Branch irrigation canals	45.2 km
Secondary irrigation canals	33.6 km
Main drainage canals	90.5 km
Secondary drain	27.0 km

Canals in Eastern Plain - A:

Main irrigation canals	7.0 km
Branch irrigation canals	30.3 km
Main drainage canals	22.5 km

Cropping Area in Western Plain:

Sugar cane	6,980 ha
Cotton	4,830 ha
Paddy	4,050 ha
Maize	2,000 ha

Beans	2,830 ha
Sesame	250 ha
Melon	2,000 ha
Water melon	200 ha
Vegetables	1,600 ha
Pasture	140 ha

Agricultural Net Return:

Western plain	Lp. 38.2 million
Eastern plain - A	Lp. 11.3 million
Total	Lp. 49.5 million

Man-power Requirement:

Western plain	9,900 man-years
Eastern plain	3,300 man-years
Total	13,200 man-years

Resettlement Possibility: 2,400 families

Irrigation Water for Middle Reach Valley

Net Irrigation Area:

San Juan de Flores area	2,680 ha
Existing area in Middle reach valley	680 ha
Total	3,360 ha

Power Generation

Annual Energy Output: 53.6 GWh

Installed Capacity:

Maximum capacity	18.2 MW
Average capacity in dry season	11.1 MW

Investment Cost

Stage-1, Phase 1-1 (Dam + 12,400 ha)

Foreign currency	Lp. 197.2 million
Local currency	Lp. 75.6 million
Total	Lp. 272.8 million

Stage-1, Phase 1-2 (3,600 ha) Lp. 30.0 million

Stage-2 (4,600 ha) Lp. 66.8 million

Economic Internal Rate of Return

Full stage implementation	14.2%
First stage implementation	13.7%
Phase 1-1 implementation	12.9%

CHOLUTECA RIVER BASIN

AGRICULTURAL DEVELOPMENT PROJECT

UPDATING FEASIBILITY STUDY

Table of Contents

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF DRAWINGS

ABBREVIATION

(Honduras Organization)

ACANSA	Azucarera Cantarrana S.A.
ACENSA	Azucarera Central S.A.
ACHSA	Azucarera Choluteca S.A.
BANADESA	Banco Nacional de Desarrollo Agrícola
COHDEFOR	Corporación Hondureña de Desarrollo Forestal
CONSUPLANE	Consejo Superior de Planificación Económica
DGEC	Dirección General de Estadística y Censos
DGRH	Dirección General de Recursos Hídricos
ENEE	Empresa Nacional de Energía Eléctrica
IHMA	Instituto Hondreño de Mercadeo Agrícola
INA	Instituto Nacional Agrario
PMRR	Proyecto Manejo de Recursos Naturales
MRN	Ministerio de Recursos Naturales
SANAA	Servicio Autónomo Nacional de Acueductos y Abcantarillados
SECOPT	Secretaría de Comunicaciones, Obras Públicas y Transporte

(International Organization)

FAO	Food and Agricultural Organization of United Nations
IBRD	International Bank for Reconstruction and Development
IDB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture

(Others)

FOB	Free on Board
CIF	Costs, Insurance and Freight
EAP	Economically Active Population
EL.	Elevation above mean sea Level
GDP	Gross Domestic Product

ABBREVIATION OF MEASURES

(Length)

mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer

(Area)

m^2	Square Meter
km^2	Square Kilometer
ha	Hectare = 1.428 Manzana

(Weight)

mg	Milligram
kg	Kilogram
ton,t	Metric Ton
qq	Quintal = 45.5 kg

(Volume)

m^3	Cubic Meter
lit	Liter
MCM	Million Cubic Meters

(Currency)

Lp.	Lempiras
US$	US Dollar = Lp.2.00 (Official Exchange rate) in mid-1984)

(Electricity)

kV	Kilovolt
kW	Kilowatt
MW	Megawatt
GWh	Gigawatt hour
rpm	Revolution per minute

(Derived)

m/s	Meter per second
m^3/s	Cubic meter per second
m^3/min	Cubic meter per minute
lit/s/ha	Liter per second per hectare
Ton/ha	Metric ton per hectare

(Other Measures)

%	Percentage
ø	Diameter
°C	Centigrade
pH	Scale for acidity
10^3	Thousand
10^6	Million

I. INTRODUCTION

1.1 Historical Background

Land and water resources development in the South region of Honduras, particularly in the Choluteca plain where sizable lands are available for agricultural development, has long been cherished by the people of the region and the Government of Honduras. The agricultural development of the Choluteca plain was first studied by an American consultant in 1968. The plan formulated by this study envisaged solving the primary constraint of dryness in the region by introducing irrigated farming for about 15,500 ha.

In 1977-78, a feasibility study on agricultural development in the Choluteca river basin was conducted by the Japan International Cooperation Agency (JICA), the executing agency for technical cooperation program of the Government of Japan. The study recommended the development of irrigation over 12,400 ha in the first stage and 16,000 ha in the second stage on the Choluteca plain and construction of dam in the upstream reach to store water for irrigation and power generation. The proposed development plan was assessed to be technically and economically feasible. However, the project has not been realized due mainly to financial reasons.

With its recent policy to accelerate agricultural and rural development, the Government of Honduras requested the technical cooperation of the Government of Japan in updating of the feasibility study made by JICA of the Choluteca river basin agricultural development project. The terms of reference for this updating feasibility study were agreed between the Ministry of Natural Resources (MRN) of the Government of Honduras and JICA on June 19, 1984.

1.2 Work Performed

In accordance with the terms of reference agreed between MRN and JICA, the updating feasibility study has been carried out by JICA team in collaboration with counterpart experts assigned by MRN and Consejo Superior de Planificación Económica (CONSUPLANE). The members of counterpart and JICA team are listed in Table 1-1. The field work, including surveys in the study area and collection of updated data and information to review changes in socio-economic and physical conditions since 1977, were carried out during the period from August 20 to September 30, 1984. Subsequently, a detailed analysis and study has been conducted in Japan for two months up to the end of November 1984.

The period allocated for the updating study was severely limited. However, some alternatives to the original plan proposed by 1977-78 study have been studied to determine the best program for implementation, in the light of recent changes and forecasts of requirements for the project. Although the study was confined, in principle, to the development of agriculture in the Choluteca plain and development of a dam and reservoir in the Choluteca river upstream, requirements for storage of water for existing and planned irrigation systems in the middle reaches of the Choluteca river have also been reviewed preliminarily in this updating study.

1.3 Reports

All the results of these investigations, analysis, studies and evaluation of the project are presented in this final report in three volumes. The Main Report in Volume I presents the study results and recommendations in a summarized form. Chapter II of the Main Report briefly reviews the general background of the project, particularly in the agricultural sector. The present socio-economic and physical conditions and present situation of agriculture in the Choluteca plain are summarized in Chapter III. In Chapter IV, the potential for development of irrigated agriculture is discussed and proposed. The water to be stored for irrigation, as well as for power generation and other purposes, is evaluated with alternatives and the best solution for the dam and reservoir scheme and the basic plan for irrigation development in the Choluteca plain are formulated in Chapter V. In Chapter VI, proposed facilities for the dam, irrigation and drainage systems and for on-farm development are outlined with preliminarily designs. The construction plan and schedule, as well as institutional and environmental aspects of the project, are discussed in Chapter VII and Chapter VIII. The estimates of costs and benefits, as well as the economic and financial evaluation of the proposed development plan, are presented in Chapter IX to Chapter XI. In Chapters XII and XIII, recommendations are made for implementation of the agricultural development in the Choluteca plain and on other actions that are suggested to be taken by the authorities concerned.

Detailed analysis, supporting data and information are presented in Annexes in Volume II and Volume III. In Annex-A to Annex-F in Volume II, the general and sectoral background, physical conditions, present and proposed agriculture are described and analysed. Details of alternative studies, preliminary designs of project facilities and evaluation of the project are incorporated in Annex-G to Annex-J in Volume III.

1.4 Acknowledgements

During execution of the updating studies, the study team, both JICA team and counterparts, received a kind assistance and cooperation from the people living in the study area, as well as from a number of public and private institutions in Honduras. The team takes this opportunity to express its heartfelt gratitude to all the personnel and institutions concerned. Without their assistance and cooperation, the study could not have been completed within such a short period. Cooperation of the Ministry of Foreign Affairs and Ministry of Agriculture, Forestry and Fishery of the Japanese Government, as well as the Embassy of Japan in Honduras, is also gratefully acknowledged. The study team sincerely hopes that the joint effort and cooperation extended to the study will contribute to agricultural development in the Choluteca plain and eventually to socio-economic development in the Republic of Honduras.

II. GENERAL BACKGROUND

2.1 Social Background

Honduras had, in its territory of 112,088 km^2, a population of 4.1 million in 1983, which has recently been increased at the average rate of 3.4% per annum. It is estimated that the population will reach 4.3 million in 1985 and 5 million in 1990 (See Table 2-1). The increase in the urban population has been remarkable. The urban population accounted for 31.5% in 1974, but was estimated to represent 38.2% in 1983. The recent growth rate in the urban population is approximately 6.1% per annum in the metropolitan district, 7.6% in San Pedro Sula and 6.5% in Choluteca city. Urbanization will be further accelerated, unless strategic measures are taken for rural development. Such a trend of rapid increase in population and urbanization, if allowed to continue, could have serious effects on future overall economic and social development of Honduras (See also Annex A.1.1).

About 53% of the economically active population (EAP), which is estimated to be around 1 million or 26% of total population of the country, are engaged in the agricultural sector. Availability of EAP in the sector is estimated to be around 700,000 persons, of whom 34% are considered to be underemployed. The unemployment rate is also high, and exceeds 15% in the metropolitan area. In this context, too, it is of prime significance that employment opportunities are created by developing agriculture in a more accelerated manner (See also Annex A.1.2).

The population of the South region, which comprises Choluteca Department and Valle Department, is estimated to be around 415,000 or approximately 10% of total population of Honduras. The population density in the two Departments are the third and fourth highest among the 18 Departments of the country. Although no statistical record was available, the seasonal underemployment is apparently high in the South region due to uneven distribution of rainfall. Since 78% of population in the Choluteca Department reside in rural areas, agricultural development is to be promoted in the region to stabilize the social and economic situation in rural areas, as well as to create employment opportunities throughout the year and to prevent further emigration to urban centers.

2.2 Recent Economic Trends

In the late 1970's, the gross domestic product (GDP) grew at the relatively high rate of 7.3% per annum. Since 1981, however, Honduras has experienced negative growth in GDP. In 1983, GDP amounted to Lp. 5,890 million at current market prices, of which the agricultural sector contributed about 25%. GDP in the agricultural sector grew at an average annual rate of 6.7% in 1975-80 and 1.6% even in 1980-83 (See Table 2-2). Agricultural products contributed nearly 78% of total commodity exports which amounted to around Lp. 1,360 million in 1983. Among the agricultural products, export of crop products such as banana, coffee, sugar, cotton, sesame, tobacco and fruits accounted for over 60% of total commodity exports (See Table 2-3 and Annex B.2.1).

The trade balance still remains negative, though it has gradually improved since 1980, with a substantial decrease in import of commodities. The import of food products decreased from Lp. 171 million in 1980 to Lp. 140 million in 1983. For further improvement in the balance of payments, the private and public investment (14.2% of total demand in 1983) will have to be directed towards export-oriented and more productive sectors of the economic activities in Honduras (See also Annex A.2.3).

Regionally, there has been less investment in economic development in the South region then in the Central and North regions of the country. As a consequence, development of the South region has been lagging. More accelerated development of the region, particularly in agricultural development of the rural areas, is required to attain more balanced regional development in the country.

2.3 Performance in Agriculture

Honduras is dominated by mountainous topography, and flat cultivable lands are limited to parts of the northern and southern coastal plains and along the valleys of major river systems. According to a study made by FAO, MRN and CONSUPLANE, flat cultivable lands amount to about 1.8 million ha, or 16% of the national territory. Further, a study by MRN and CONSUPLANE indicated that the irrigable land in Honduras is limited to about 0.4 million ha. Consequently, it is really important for Honduras to utilize its limited agricultural lands to the maximum extent (See Table 2-4 and Annex B.1.1).

Cultivation of staple crops (maize, beans, sorghum and rice) was practised over about 0.5 million ha in 1981-82. Although production of grain was insufficient up to year 1980, and the country depended on imports to meet domestic demand, it is said that increased grain production in recent years has attained quasi-selfsufficiency in grain supply. It is noted, however, that a potential demand for grain, particularly rice which has elasticity to increases in income level, still exists and production is to be increased to satisfy the potential demand and to meet the growing demand of the rapid increasing population. Further, produductivity of grain cultivation remains at a low level, and productivity is vulnerable to climatic conditions (See Table 2-5 and Annex B.1.2).

Cultivation of sugar cane and cotton is climatically favoured in the South region. Out of the total sugar produced by 8 sugar mills in Honduras, about 29% or 1.3 million tons were produced by the two sugar mills in the Choluteca plain. Although the cropped area and production of cotton has recently decreased, the South region produced around 66% of cotton in Honduras. Cultivation and production of melon, water melon and sesame have also increased in the South region.

Agrarian reform has been laboriously promoted in Honduras since 1975. About 1,630 groups with a total of over 44,100 families have been organized by Instituto Nacional Agrario (INA) on the land acquired over

275,000 ha. Under the Agrarian Reform Law, the holding size of land is at present limited to 500 ha on the coastal plain of the South region, but it will be restricted to a maximum of 100 ha if a State irrigation system is executed. Land exceeding such limitations, as well as land inefficiently utilized, is subject to expropriation under the law (See also Annex B.1.3).

2.4 Agricultural Development Programs

The National Development Plan 1982-86 gives priority to fostering agricultural development. The objectives of the sectoral plan for agricultural development were set forth to increase production and productivity to meet domestic demand and expand exports, and to improve and rationalize the use of available human and natural resources. The plan envisages an annual growth rate of 6.3% in real value added in the agricultural sector during the plan period. To attain such objectives, the plan indicates targets for increases in production and areas for cultivation. For example, cultivation of such crops as maize, rice, sesame, pineapple, tomato and melon is planned to be increased. No increase in sugar cane and sorghum cultivation area is contemplated under the plan (See Table 2-6). In the field of agrarian reform, the National Development Plan envisages resettlement of some 26,400 families on 163,200 ha to be expropriated in 1983-86 (See also Annex B.1.5).

The National Plan for Water Resources Development proposes that irrigation systems in the Choluteca plain should be taken up as one of the highest priority projects. Priority is also accorded to consolidation of existing irrigation systems. Such schemes as the Ola and Buana Vista irrigation projects listed in the national plan will be incorporated in the Choluteca project if it is implemented.

2.5 Background in Other Sectors

If a dam and reservoir are to be constructed for development of irrigated agriculture, it is possible that such a dam will also serve for generation of hydroelectric power, water supply and other purposes. To frame a concept for development of the Choluteca river basin, electric power and water supply in Honduras are briefly reviewed.

Electric power is supplied by the Empresa Nacional de Energia Eléctrica (ENEE) throughout the country. ENEE's central interconnected grid is presently fed by hydro and thermal power plants with a total installed capacity of some 230 MW (131 MW in hydro and 99 MW in thermal). The energy sold in the grid was approximately 900 GWh and the maximum demand was around 181 MW in 1983. According to the forecast by ENEE, the maximum demand will reach 344 MW in 1990, 426 MW in 1993 and 670 MW in year 2000. El Cajon hydroelectric project (292 MW in installed capacity and 986 GWh in firm energy output), scheduled to be completed in 1985, will meet demands up to 1993. Since the power supply is expected to become critical in or around 1994, ENEE intends to initiate studies on other hydroelectric projects. ENEE is therefore interested in generating hydropower by utilizing water which would be stored principally for irrigation in the Choluteca river basin (See also Annex B.2).

The demand for water supplies in the metropolitan area has been sharply increasing in line with the rapid growth in population in the Central District. Servicio Autónomo Nacional de Acueductos y Alcantarillados (SANAA) estimates that the demand will reach around 111,000 m^3/day in 1990 and 240,000 m^3/day in 2000. Since the present water supply capacity is limited to 88,800 m^3/day, SANAA has prepared a master plan for production of potable water, which contemplates development of 4 storage schemes, 2 water diversion schemes and 2 groundwater exploration schemes. A detailed design for the priority project (Guacerique project with a capacity of 88,200 m^3/day) has also been prepared. It is observed that the cost of water to be produced by projects proposed by the master plan is quite high (See also Annex B.3.1).

Water demand in Choluteca city is also increasing rapidly. The present water supply capacity is limited to 4,400 m^3/day, or less than a half of the potential demand in the city. In view of the water quality and cost, it is considered desirable that the limited groundwater resources of the Choluteca plain should be reserved and utilized for potable water supplies, rather than for expanding groundwater irrigation schemes on the plain.

2.6 Framework for the Project

From a review of the social and economic background, it is apparent that development of agriculture in the Choluteca plain should be planned within the framework of government policies summarized below:

a) Agricultural production has to be increased to meet domestic demand, which is expected to grow in line with a rapid increase in population. Production, which is vulnerable to climatic conditions, should be stabilized to the maximum extent.

b) Production of crops, including industrial crops, is to be increased to promote exports and improve the balance of payments. Stabilization of export and industrial crop cultivation is to be also attained.

c) Productivity of crop cultivation has to be improved, in view of the fact that flat cultivable land is severely limited in Honduras. Year-round cultivation is looked for higher production per unit of land.

d) Agrarian reform programs are to be promoted and stabilized to increase the income of small farmers, as well as cooperatives and resettlements.

e) Employment opportunities have to be created in agriculture and agro-based industries. Seasonal underemployment needs to be minimized to increase income and stabilize livelihood.

f) Rural development is required through development of agriculture, together with better balanced regional development.

g) Water resources have to be better used for agricultural development. A dam and reservoir envisaged for the purpose should be developed to serve multiple purposes.

III. THE CHOLUTECA PLAIN

3.1 Social Conditions

The study area in the Choluteca plain is provisionally divided into two areas: one on the right bank of the Choluteca river (called the Western plain) with a gross area of 22,400 ha, and the other on the left bank of the river (called the Eastern plain) with a gross area of 13,600 ha.

The population in the study area is estimated to be about 22,600 persons in total, or about 17,400 persons in the Western plain (78 persons/km2) and about 5,200 persons in the Eastern plain (37 persons/km2). The total number of household is also estimated to be around 4,500, of which around 3,800 households are presumed to be dependent on agriculture. The agricultural population totals approximately 19,100 persons (about 14,700 persons in the Western plain and 4,400 persons in the Eastern plan). It is further estimated that the available agricultural work force will be nearly 2.5 million man-days a year (See Table 3-1 and Annex E.1).

Landless farmers are relatively large in number. Farmers holding less than 10 ha of land are about 530 families, and their lands are 2,340 ha or 7.3% of the total study area. Also there are 25 agricultural cooperatives and resettlement groups (about 380 families) who hold the land of about 2,370 ha (about 1,980 ha in the Western plain and 390 ha in the Eastern plain). On the other hand, about 20 large-scale landowners hold 4,530 ha of land in the Western plain, and other 20 landowners hold 7,530 ha in the Eastern plain. Further, two sugar factories hold estates of 3,530 ha in the area (See also Annex E.2).

Living standards of small farmers, cooperatives and resettlement groups in the Choluteca plain are still substantially low. It is mainly because farming in the region is so vulnerable to climatic conditions and productivity is generally so low. Farmers' income is also unstable in the area for the same reasons.

3.2 Climate

The climate of the Choluteca plain is favorable for agriculture, except for the problem of uneven distribution of rainfall. The plain has a tropical or semi-tropical climate. The mean monthly temperature at Choluteca meteorological station shows little variation throughout the year, ranging from 27.1°C in September to 30.9°C in April. Daily variations in temperature range between 8°C and 12°C. The annual mean relative humidity is around 61%, and it fluctuates between 50% in February and 81% in September (See Figure 2-1). North to northeast winds prevail in the dry season and east to south winds in the rainy season. The monthly average of the daily maximum wind velocity ranges from 9.9 km/hour in September to 20.5 km/hour in January.

Rainfall in the Choluteca plain is characterized by uneven seasonal distribution. The average annual precipitation is approximately 1,910 mm at Choluteca meteorological station (1943-83 records). Over 93% of the annual precipitation is concentrated in the rainy season from May to October (See Table 3-2), and effective rainfall in the dry season from November to April is very limited. According to the precipitation records at Choluteca station and at ACENSA station, the mean monthly 80% probable rainfall is limited to 5.7 mm in December, 1.9 mm in January and 7.3 mm in March. Effective precipitation is much less. Such a long and severe spell of dryness is the most serious constraint for development of the Choluteca plain and for the region as a whole.

The Choluteca plain has also a dry spell in July - August (locally called "canicula"). This lasts for about four weeks in Choluteca. For reference, the mean monthly 80% probable rainfall drops to around 78 mm in July and 126 mm in August, while the rest of rainy months have 80% probable rainfall over 200 mm. The "canicula" often causes damages or decreases productivity in crop cultivation.

Mean annual evaporation (A-pan) at Choluteca is around 2,900 mm. The monthly mean evaporation ranges from 158 mm in September to 340 mm in March. Potential evapotranspiration at Choluteca is estimated to be around 2,400 mm on an annual average. This ranges from 113 mm in September to 275 mm in March (See also Annex C.2 and Annex H.1).

3.3 Hydrology

The Choluteca river which divides the Choluteca plain has a total catchment area of approximately 7,580 km^2. Hydrological records for the lower Choluteca river basin are only available at Los Encuentros gauging station (1956-73 and terminated thereafter) with a catchment area of 6,370 km^2, and at Choluteca Bridge gauging station (1979-83) with a catchment area of 6,930 km^2. The discharge at the possible intake weir site at El Papalon (catchment area of 7,115 km^2) has been estimated on the basis of these records.

At El Papalon, the annual runoff is estimated to be about 1,480 million m^3. The mean monthly runoff drops to 45.5 MCM (17 m^3/s) in December, 16.9 MCM (7 m^3/s) in February and 13.9 MCM (5.2 m^3/s) in March. The mean monthly runoff remains at 15.2 MCM (5.9 $M3/s$) in April. The daily discharge often drops even further (See Table 3-3 and Annex C.3).

In the dry months, existing irrigation schemes in the Choluteca plain are pumping water from the Choluteca river. Such schemes cover an area of some 3,500 ha. Consequently, the discharge in the downstream reaches is insufficient even for the existing irrigation area, and this sometimes causes social and environmental problems.

On the other hand, the flood discharge at El Papalon is estimated to be about 1,040 m^3/s for a return period of 5 years and 1,330 m^3/s for a return period of 10 years. Since the flood conveyance capacity of the Choluteca river downstream from the confluence with the old river course is limited, the lower Choluteca plain is subject to periodic inundation even though it usually lasts for a relatively short period (See also Annex C.4).

3.4 Soils and Land Capability

The Choluteca river basin is dominantly covered with Tertiary volcanic rocks, composed of acidic pyroclastic rocks, lava flow of rhyolite, andesite and basalt. The Tertiary sedimentary rocks and Quaternary volcanic rocks are observed in places. Quaternary sediments are extensively deposited in the flat plain. Topographically, the lower Choluteca river basin is classified into hill masses, terraces and alluvial plain. The alluvial plain is covered by soils of Inceptisols, Entisols and Mollisols, while the terraces are covered by Alfisols, Vertisols and Ultisols. The hill masses in the Choluteca plain are also covered by Alfisols.

On the Western plain on the right bank of the Choluteca river, the alluvial plain covers over 19,140 ha, the terraces over 2,030 ha and hill masses over 300 ha. The alluvial plain is mostly covered with Mollisols (15,960 ha or 71% of the Western plain). Mollisols are fine sandy loam to loam in texture in surface soil and loamy to loamy clay in subsoil. Mollisols are fertile to moderately fertile, with moderate to imperfect drainage, and they are suitable for cultivation of all upland crop and rice under irrigation with proper drainage. Part of the alluvial plain is covered with Entisols (2,770 ha or 12%), which are sandy loam to silty loam in texture in surface soil and fine loam to silty clay or clay in subsoil. Entisols are fertile and well drained, and are suitable for irrigated farming of all upland crops. A small part of the alluvial plain is covered with Inceptisols (410 ha or 2%), which are also fertile and suitable for upland crop cultivation. Poor water retention is a limitation for rice cultivation in Inceptisols and Entisols (See Table 3-4, Figure 3-1 and Annex D.4.1).

Terraces of the Western plain cover 2,030 ha, and composed of Vertisols (1,410 ha) and Alfisols (620 ha). Vertisols are developed in the Ola district in the northwestern corner of the plain. Vertisols have texture of clay to fine clay in surface and fine clay in subsoil. They are fertile but imperfectly drainable. Vertisols have no limitation for rice cultivation, but proper drainage has to be provided for upland crop cultivation. Alfisols in the terraces are moderately fertile and imperfectly drainable, and they are cultivated for upland crop and rice.

Land capability on the Western plain is classified into Class I (6,740 ha or 30% of the Western plain), Class II (6,750 ha or 30%) and Class III (7,590 ha or 34%). Marginally suitable and unsuitable land is only limited to 390 ha (less than 2%) (See Table 3-5, Figure 3-2 and Annex D.4.2).

On the Eastern plain on the left bank of the Choluteca river, the terraces are widely developed. Terraces of Alfisols cover 10,930 ha or 80% of the Eastern plain, and terraces of Vertisols and Ultisols cover 610 ha (4%). Alfisols are sandy loam in texture in surface and silty clay to clay in subsoil. They are moderately fertile, but relatively stony. Alfisols are suitable for cultivation of rice and upland crops. Since drainability is imperfect, cultivation of upland crops requires proper drainage systems. Vertisols are fertile and Ultisols are fertile to moderately fertile. They are suitable for rice and upland crop cultivation. For upland crop cultivation, proper drainage has to be provided. The Eastern plain is partially composed of the alluvial plain of Inceptisols (180 ha), Entisols (690 ha) and Mollisols (180 ha). They are also fertile and suitable for crop cultivation.

Land capability on the Eastern plain is classified into Class I and Class II (1,530 ha in total), as well as into Class III (9,350 ha). Marginally suitable and unsuitable land is approximately 2,500 ha on the Eastern plain.

3.5 Present Land Use and Farming Practices

About 86% of the project area is agricultural land. This land (19,680 ha gross) on the Western plain is presently cultivated for upland crops (11,070 ha), paddy (50 ha) and pasture (6,310 ha), or is covered by forest (2,250 ha). The net cultivated area is about 7,880 ha for sugar cane, 1,050 ha for maize, 230 ha for cotton, 150 ha for sesame, 120 ha for sorghum and 40 ha for paddy. The area cultivated for melon and water melon has increased to 1,150 ha. On the Eastern plain (11,360 ha gross), a greater proportion of land is currently used as pasture land (5,250 ha). The net cultivated area is 700 ha for paddy, 450 ha for sugar cane, 200 ha for maize and 90 ha for cotton (See Table 3-6 and Annex E.3.1).

In the project area of the Choluteca plain, there are several existing irrigation systems, covering approximately 4,500 ha. On the Western plain, the estates of two sugar factories have 2,300 ha under irrigation from the Choluteca river and about 880 ha from groundwater, and a sugar cane grower is irrigating about 70 ha. On the Eastern plain, ACENSA sugar factory has irrigation facilities for 300 ha, and four sugar cane growers have irrigation systems for around 110 ha. A 700 ha rice estate has recently been developed, which uses water pumped from the Choluteca river (See also Annex E.4.4).

Apart from cultivation of sugar cane and irrigated rice, upland crops are seasonally cultivated in depending on climatic conditions. In general, these are planted in the rainy season and grown by rainfall and soil moisture at the beginning of dry season. Farming in the Choluteca plain is semi-mechanized.

Sugar cane is cultivated by two sugar factories and outgrowers contracted with these factories. NC0310 and other varieties tolerant to dryness are prevalent. The growth period is 13 - 16 months for plant cane and 11 - 12 months for ratoon cane. Ratoon is usually practised 4 - 6 times, depending on soil conditions. Sugar cane is harvested from November to May, with an average yield is in the range of 60 - 80 tons/ha, but some lands with better soil moisture produce more than 140 - 150 tons/ha.

Cotton is cultivated by members of Cooperativa Agropecuaria Algodonera del Sur. Although cotton cultivation area has recently decreased on the Choluteca plain, the plain is climatically suitable and produces a good quality of cotton. Stanville 213 is the preferred variety.

It is planted in July - August and harvested in January - March. The yield is vulnerable to climatic conditions, and it is around 2.3 tons/ha on the plain.

Maize is cultivated as a staple crop under rainfed conditions. The first cropping season is May to September, and the second August - September to December. Preferred varieties are HB104 and Santa Rosa, which have a growing period of 110 - 120 days. Yields of semi-mechanized maize cultivation are about 2.0 tons/ha. Cultivation of sorghum is relatively limited in the project area. It is sown in May and harvested in August. The yield of sorghum is about 1.9 tons/ha under semi-mechanized farming on the plain. Sesame is grown on relatively small scale. The most popular varieties of sesame, Instituto 71 and Venezuela 44, are sown in August - September and harvested in 90 - 110 days. Present yields are low, or around 0.7 ton/ha.

Rice cultivation on the Choluteca plain is practised mainly under irrigated conditions. The first crop is planted in February - March and harvested in June - August, and the second crop is sown in July - August and harvested in December - February. Direct sowing by airplane and transplanting by hand are both practised. Grain combines are used for harvesting. The most prevalent variety on the plain is CICA-8, with a yield of around 4.5 tons/ha under irrigation.

Melons are cultivated mainly for export. To satisfy the USA east coast market, it must be harvested in November - February. The SJ45 variety is grown in September - October to December - January and the Tan Dew variety is grown in October - November to January - February. Water melons, on the other hand, are cultivated for local market. The prevalent variety of sugar-baby has a growing period of around 100 days. The cultivation of sugar-baby is similar to that of Tan Dew melon.

Livestock breeding is widely practised on the Choluteca plain. About 70% of pasture land is cultivated for improved pasture grasses such as Estrella Africana, elephant grass, Guinea grass, etc.

The cattle population is estimated at aroud 36,000 - 37,000, or approximately 2 head/ha. Cattles become emaciated in the dry season, though they are mostly transfered to places where grasses are available. The livestock yield is estimated to be about 130 kg of meat and 190 liters of milk per ha (See also Annex E.4.2).

3.6 Production

Present agricultural production in the Choluteca plain is estimated on the basis of unit yields investigated in the field and net cultivated area. Total production is estimated to be about 649,300 tons of sugar cane, 740 tons of cotton, 2,330 tons of maize, 170 tons of sorghum, 6,660 tons of paddy, 120 tons of sesame, 5,800 tons of melon and 560 tons of water melon. Production of meat and milk is also estimated to be about 2,370 tons and 3,470 kℓ, respectively (See Table 3-7 and Annex E.3.2).

Potential future production under the "without" project condition is also estimated. In view of the physical conditions on the Choluteca plain, particularly the constraints of the rainfall pattern, it is generally presumed that there will be no substantial change in the cropping area and yield in future under the "without" project condition. It is assumed that sugar cane production could be slightly increased to reach 760,300 tons and cotton production to reach around 2,050 tons. It is also assumed that production of maize and melon could increase slightly to 2,500 tons and 6,400 tons, respectively. Production of other crops in the area is assumed to remain at the present level even under the "without" project condition (See also Annex E.6.2).

3.7 Supporting Services

Institutional supporting services for farming in the Choluteca plain are provided by MRN, INA, BANADESA and IHMA. MRN provides research and extension services, as well as seed multiplication, lease of agricultural machinery, and training of farmers through the extension agents.

The Choluteca plain is covered by 3 extension offices, and a total of 4 extension workers, 2 experts in cotton and 2 veterinery experts are serving at present. The experimental station at La Lujosa serves for agricultural research and seed multiplication. There is also at La Lujosa, a regional training center for farmers, cooperatives and technicians. A mechanical center is located in Choluteca, which provides services for mechanized farming. The services provided by MRN has been gradually improved, but they are still considered to be insufficient for accelerated agricultural development in the region.

INA provides supporting services for 25 cooperatives and resettlement groups organized under the Ola - Monjaras resettlement project. INA agent also provides technical services, as well as machinery services, to the groups from time to time. BANADESA is responsible for provision of agricultural credits, and in 1983 BANADESA's Choluteca office extended 3,800 credits totaling Lp. 17 million. Prevailing conditions of the credit are relatively hard. For instance, the interest rate is 13% for the reformed groups and 15.58% and 19% for ordinary loans. The size of loan is also said to be insufficient. IHMA is responsible for marketing of staple crops, though its services cover only about 15% of total production. Guaranteed prices are fixed annually by IHMA (See also Annex B.1.4 and E.5.1).

3.8 Agro-industries and Marketing

On the Choluteca plain, there are two sugar factories; ACHSA (milling capacity of 2,000 tons/day) operated since 1968 and ACENSA (4,500 tons/day) operated since 1977-78. They are operated for around 150 days (net) a year during the dry season, with an average sugar recovery rate of approximately 7.7%. The contracted outgrowers were paid the mill gate price of Lp. 31/ton in 1983-84. The crude and white sugar produced by ACHSA and ACENSA, as well as by 6 other member factories of the Association of Sugar Producers in Honduras, is marketed through BANASUPRO.

A cotton ginnery of the cotton cooperative is located at San Lorenzo, with a capacity of approximately 20 tons/hour of seed cotton. This has been under-utilized in recent years. Member farmers were paid Lp. 1,256/ton in 1983-84. About 94% of the cotton fiber is exported, and the remaining 6% is used locally. The export price of cotton fiber was Lp. 3,429/ton in 1983-84. Cotton seed is sold at Lp. 308/ton to the seed oil factory located near the ginnery. Seed oil is used for production of margarine and soaps.

A processing plant for sesame has recently been installed near Choluteca, with a processing capacity of some 9,000 tons/year. Sesame is purchased at Lp. 1,035/ton, and the processed sesame is exported at Lp. 1,545/ton. There are two privately operated rice mills, with a total capacity of 80 tons/day. Another rice mill of 120 tons/day is scheduled to be installed by 1986 at a grain silo being constructed near Choluteca city. Rice, as well as other staple crops, is generally sold at guaranteed prices set by IHMA.

For the export of melons, there are 7 packing plants in the region operated by a cooperative, a private farm and 2 private companies. Melons are sold to these organizations at prices set bi-monthly in December - February.

There are two slaughter houses in Choluteca with a slaughtering and packing capacity of about 400 carcases/day, which is much larger than the regional requirement for processing. No dairy processing plants are available on the plain, except for some home processing (See also Annex E.5.2 and E.5.3).

3.9 Agricultural Return

The net return from agriculture in the project area of the Choluteca plain is estimated under the present and "without" project conditions, on the basis of the agricultural production noted in Chapter 3.6, as well as the estimates of gross revenue and expenditure.

It is estimated that annual net return from agricultural production under the present situation amounts to around Lp. 16.5 million (about Lp. 13 million on the Western plain and Lp. 3.5 million on the Eastern plain). Under the "without" project condition, some increase in production of sugar cane, cotton, melon, etc. may be expectable. However, the net agricultural return in the project area is not expected to increase to any great extent, or to approximately Lp. 19 million. The net agricultural return under the present and "without" project condition is thus quite small, despite the large agricultural potential of the Choluteca plain (See also Table 3-8 and Annex E.6.3).

The present agricultural net return to the farmers and cooperatives has also been reviewed. A typical farmer with a land holding of 10 ha is expected to earn a net return slightly over Lp. 1,100 per annum, while a typical cooperative with 15 members on 100 ha is assumed to get a net distributable profit though such profits are also poor. Such a net return from agriculture is unstable principally due to vulnerability to weather conditions (See also Annex E.5.4).

IV. POTENTIAL AGRICULTURAL DEVELOPMENT

4.1 Irrigated Agriculture

As discussed in Chapter III, the Choluteca plain has favorable land resources for agricultural development. The most fundamental constraint for the development is the uneven distribution of rainfall in the region. As noted in Chapter 3.2, over 93% of the annual mean rainfall is concentrated in the rainy season from May to October, and the driest months from December to March have little or less than 1% of annual rainfall. The problem of such a long dry spell can be solved by application of irrigation. The potentially agricultural land can be fully developed by introduction of irrigated agriculture in the Choluteca plain. Fortunately, water is available in the Choluteca river, running in the center of the Choluteca plain.

Introduction of irrigated agriculture on the Choluteca plain will respond to the requirements for development framed in Chapter 2.6. Irrigated agriculture would not only solve the problem of dry spell, but would stabilize the production throughout the year. Agricultural production and productivity would be greatly increased by year round irrigation application. Agricultural activities would be intensified, and employment opportunities will increase and expand to reduce unemployment and seasonal underemployment. Eventually, it would bring farmers a higher and more stable income, and would contribute to the rural development and balanced regional development. The agricultural development to be proposed in the Choluteca plain will therefore be planned on the basis of irrigated agriculture.

4.2 Irrigable Area in Choluteca Plain

Land on the Choluteca plain (36,000 ha) is classified into the agricultural land and non-agricultural land (villages, roads, rivers, etc.). Of 22,400 ha of land on the Western plain, 16,000 ha has been identified as agricultural land irrigable by water from the Choluteca river.

Land along the coast, within approximately 7 km from the coastal line, is affected by salinity to some extent. The salinized land was precluded from the irrigable area, though it can be utilized as pasture land.

On the Eastern plain, the agricultural land is estimated to be about 9,800 ha, or about 72% of the 13,600 ha of the project area on the left bank of the Choluteca river. The agricultural land on the Eastern plain is provisionally divided into two blocks for convenience of studying irrigability by water to be stored in the reservoir to be constructed by the project. The Eastern plain - A encompases relatively flat agricultural land of some 4,600 ha, while the Eastern plain - B covers about 5,200 ha in the northeastern part of the terraces developed on the left bank of the Choluteca river. This agricultural land is irrigable if enough water can be made available by the reservoir.

4.3 Major Crops

Major crops to be proposed for irrigated farming on the Choluteca plain need to be selected basically in the light of i) national policy and strategies for agricultural development, ii) adaptability to local conditions such as climate and soils, iii) productivity and profitability under irrigated conditions, iv) marketability of products in domestic and international markets, and v) familiality of crop cultivation to local farmers.

Sugar cane cultivation is well established on the Choluteca plain and should continue to be one of the main crops. Sugar cane cultivation is therefore proposed to satisfy the standard milling capacity of existing sugar factories (6,500 tons/day in total). The annual requirement from the project area is estimated to be around 857,000 tons, and it is proposed that 6,980 ha be allocated for sugar cane cultivation. Cotton would be another industrial crop to be cultivated on the Choluteca plain. The climate and soils are favorable for cotton cultivation, and a ginnery plant, seed oil factory and port for export are all available nearby and under-utilized. Although the international market price of cotton fibre fell in 1981-83, the market is open and fibre quality is competitive internationally. Since cotton cultivation is comparatively profitable, it is proposed that the area for cotton cultivation be expanded in the area.

Cereal crops such as maize and rice would be planned to meet the growing domestic demand or to substitute for imports. Maize cultivation is planned to meet the potential demand of the South region, which is preliminarily estimated to be around 40,000 tons/year in 1990. Since regional maize production is presently limited to around 20,000 tons/year, it is proposed that the cultivation area be increased by approximately 4,600 ha in the Choluteca plain. With respect to rice, present demand is rather limited, but the potential demand is considered to be substantial. The potential demand for rice in the country is preliminarily estimated to exceed 83,000 tons/year in 1990, and an additional 13,000 ha of irrigated paddy fields will have to be developed by that time. Productivity of rice in the Choluteca plain is relatively high, if water supplies are secure. Under such conditions, rice cultivation will be proposed on the land where soil conditions are favorable (Vertisols, Molisols and Alfisols) or where soil suitability is limited to rice cultivation due mainly to poor drainability.

Melons and horticulture will also be developed on the plain. Melons have favorable and assured market for export, and their cultivation will be planned to be nearly doubled. Cultivation of vegetables will also be increased to improve the farmers' economy and diet, as well as to satisfy domestic demand and possible future export of the products.

Beans and sesame will be introduced as second crops in the proposed rotational farming under irrigation. Bean cultivation is also desirable from the veewpoint of soil conservation. On the other hand, pasture is proposed for cultivation on the land where soils are stony or classified as Class IV (See also Annex F.1.1 and F.1.2).

4.4 Potential Land Use and Cropping Patterns

These are potential irrigable lands on the Western plain (irrigable land of 16,000 ha), Eastern plain-A (4,600 ha) and Eastern plain-B (5,200 ha). The irrigable land on the Western plain is proposed to be utilized for upland crop cultivation (11,810 ha), paddy field (4,050 ha) and pasture land (140 ha). Upland crop cultivation is planned for 2,300 ha on the Eastern plain-A and 2,200 ha on the Eastern plain-B, and paddy field cultivation for 2,300 ha and 1,000 ha, respectively. The undulating and stony land on the Eastern plain-B will be utilized for pasture, as shown in Table 4-1 (See also Annex F.1.3).

Cropping patterns to be proposed in respective plains were studied after careful review of natural conditions in the area, particularly climatic conditions. The proposed cropping pattern on the Western plain is illustrated in Figure 4-1. The total cropping area will be 24,880 ha, with a crop intensity of approximately 1.6, as shown in Table 4-2. On the Eastern plain-A and Eastern plain-B, rotation of paddy with maize or beans, as well as cotton with maize and beans, is proposed as shown in Figure 4-1. As compared with the "without" project conditions, the cropping area would be increased by 11,110 ha (See also Annex F.1.4).

4.5 Proposed Farming Practices

Under irrigated cultivation, farming practices will be improved in various ways, such as in the cropping calendar, varieties, fertilizer and chemical applications, mechanization, etc. For sugar cane cultivation, large stalk varieties such as B34-62, CP3437 and Pinder could be recommended under year round irrigation. Plant cane would be planted in November-March and harvested in 12-14 months, while ratooning would be done in November-May and harvested in around 12 months. Furrow irrigation at a rate of 7.1 mm/day at intervals of 10-15 days is proposed. The field would be dried out for 30 days before harvest to obtain higher sugar recovery. Proper harvest scheduling by measuring the Brix value would be indispensable. Fertilizer and chemical applications, land preparation, leveling and earthing would all be mechanized. Top-dressing and harvesting will be manual.

For cotton cultivation, Stoneville 213 and other improved varieties could be recommended. After land preparation in June - July, seeding will be done in July - August at a seeding rate of 25 kg/ha. Irrigation would be applied at rate of 6.8 mm/day at intervals of 7 - 14 days. Fertilizer and harbicides would be applied as required, and insecticides 10 - 20 times during the cycle. Land preparation, seeding, fertilizer and chemical application, and tilling would all be mechanized. Cotton would be harvested in January - March.

Paddy fields are prepared in January - March, and seeds are sown in February - April at a rate of 70 - 80 kg/ha. CICA-8 and other improved varieties could be recommended. The fields would be flooded from 20 - 25 days after seeding until one month before harvest, except for drying-up for 20 days before young panicle formation. Deep flooding between young panicle formation and heading is important. Fertilizer and herbicides would be applied. Spraying for control of blast, stem borer and aphis will also be practised. Rice is harvested in July - August.

Maize and beans are cropped in two seasons. The first crop of maize is sown in February - April and harvested in June - Jyly, while the second crop is seeded in October - November and harvested in January - March. Such varieties as HB104, ICTA-85 and Honduras planta baja are recommended. Seed rates would be around 16 kg/ha. Fertilizers, herbicides and insecticides would be applied as required. Similarly, the first crop of beans would be sown in February - April and harvested in June - July. The second crop would be sown in October - November and harvested in January - March. Seeds are inoculated with leguminous bacteria, and sown at a rate of 45 kg/ha. Land preparation, seeding, fertilizer and chemical application and tilling would be mechanized for cultivation of maize and beans.

Sesame would be sown in October - November and harvested in February - March. Strip seeding at the rate of 3 kg/ha would be carried out manually. Thinning would also be done 15 - 20 days after germination. Fertilizers, herbicides and insecticides would be applied as required (See also Annex F.2.1).

Monthly labor requirements under the farming proposed in the irrigable area have been estimated. The peak labor requirement will occur in January - March, when it reaches around 400,000 man-days/month in the Western plain. Supply of the necessary labor in the project area will be quasi-manageable in these months, but the labor force for cultivation in the Eastern plain will have to come in part from the urban zone in Choluteca. The annual man-power requirement for cultivation is estimated to be around 9,900 man-years on the Western plain and 3,320 man-years on the Eastern plain (See also Annex F.2.2).

Extension services have to be expanded and strengthened to give greater guidance on application of improved farming techniques to farmers, particularly to small farmers, resettlement groups and cooperatives. It is estimated that the area to be covered per extension worker should be no more than 1,000 ha of farm land. Consequently, it is proposed that the number of extension workers should be increased to 16 in the Western plain and to 9 - 10 in the Eastern plain. The technical knowledge of extension workers has also to be strengthened by training, particularly in the field of irrigation techniques. Training at the Agricultural Development Training Center (CEDA) in Comayagua and at La Lujosa experimental station is to be intensified. In addition, there should be further systematic research on crop adaptation, variety trials, fertilizer and chemical application tests to be made at La Lujosa station (See also Annex F.2.4).

4.6 Anticipated Production

With the introduction of irrigation and improved farming practices as proposed in the foregoing Chapters, the average yield of each crop is expected to increase substantially. The target yield of plant cane and ratoon cane would be around 125 tons/ha on an average. The target yield of cotton would also be increased to about 3.5 tons/ha and its production will be stabilized. For cultivation of paddy and maize, the target yields would be 5.0 tons/ha and 4.5 tons/ha, respectively. Productivity of beans and sesame would also be raised to 2.0 tons/ha and 1.5 tons/ha. Likewise, higher yields of melons, water melons and vegetables may be expected. The target yield from livestock would also be increased to around 195 kg/ha of meat and 285 lit/ha of milk. Such target yields will be planned, under this study, to be attained within a build-up period of about 5 years (See also Annex F.3.1).

Anticipated production under modernized irrigated farming was estimated for each area. On the Western plain, the annual sugar cane production would reach 856,000 tons. Production of cotton in the plain is expected to be around 16,900 tons. Annual production of paddy and maize will be around 20,000 tons and 9,000 tons, respectively. Likewise, the annual production of beans and sesame would be increased to 5,700 tons and 380 tons. Production of melons, water melons and vegetables are also expected to increase substantially. On the contrary, livestock production on the Western plain will have to be decreased. On the Eastern plain - A, annual production will reach 11,500 tons of paddy, 10,300 tons of maize, 8,000 tons of cotton and 4,600 tons of beans. On the Eastern plain - B, the production will reach 7,700 tons of cotton, 7,200 tons of maize, 5,000 tons of paddy and 3,200 tons of beans (See Table 4-3 and Annex F.3.2).

Agricultural net return from the proposed development was estimated, in financial terms, to be around Lp. 38.2 million on the Western plain and Lp. 19.7 million on the Eastern plain. The total net return will be increased from Lp. 19 million under the "without" project condition (See Chapter 3.9) to Lp. 57.9 million, or nearly three times as much "with" the project (See Table 4-4 and Annex F.3.3).

4.7 Resettlement Possibilities

Under the Agrarian Reform Law, the land holding size is limited to 100 ha on the area where irrigation facilities are provided by the state. In the Choluteca plain, there are some large holders of land who will be affected by the law. In the Western plain, some 19 large holders would be affected and the land expropriable by the law is estimated to be around 2,430 ha. About 20 large holders on the Eastern plain will also be affected, with expropriable land of around 5,600 ha. If such lands are redistributed to settlers at 5 ha per family, about 490 families could be resettled on the Western plain and about 1,120 families on the Eastern plain (See also Annex F.4).

Further, in the area of existing Ola - Monjaras resettlement project, it will be possible to consider expansion and consolidation of some 560 families on about 2,830 ha of land which is not settled at present. Consequently there is a possibility of promoting resettlement of about 2,170 families on around 10,900 ha. The resettlement programs have to be formulated and executed separately by INA (See Table 4-5).

4.8 Possible Irrigation in Middle Reach Valleys

In the middle reach valleys of the Choluteca river between Choluteca city and a possible damsite in the upstream reach, there are irrigation schemes that utilize mainstream water of the Choluteca river. The main schemes are in the San Juan de Flores valley, the Orocuina valley and the terraces lying to the northeast of Choluteca city (Orocuina - Choluteca area).

In the San Juan de Flores valley, there is a sugar factory (Azucalera Cantarrana S.A: ACANSA) with a milling capacity of 2,300 tons/day. The existing irrigation system covers 1,630 ha and non-irrigated cultivation is carried out on 1,050 ha. In view of the shortage of sugar cane for ACANSA, it is proposed that a total area of 2,680 ha should be irrigated solely for sugar cane cultivation. The target yield will be 100 tons/ha or 268,000 tons/year.

In the Orocuina valley, 5 small irrigation schemes have been developed by MRN-FAO (Las Sabilas, La Trinidad, San Rafael, El Brasil and Los Limones). Although the irrigation is presently applied to a very limited area (35 ha), these schemes have to be rehabilitated to serve a total of 330 ha as originally planned. It is proposed that the land be irrigated for paddy (160 ha), rotation of maize and beans (150 ha) and for vegetables. Further, in the Orocuina - Choluteca area, there is a rice estate equipped with irrigation systems, with a net area of 350 ha. In securing water supplies, priority would be given to providing for irrigation of 680 ha in the middle reaches (See also Annex F.5).

Potential irrigable areas were also identified in the Morolica valley (300 ha) and the Orocuina valley (1,340 ha). Water allocation for these areas would be considered if excess water is available from the reservoir envisaged to be constructed by the project.

V. ALTERNATIVE WATER RESOURCES DEVELOPMENT PLAN

5.1 Storage by San Fernando Dam

The natural flow of the Choluteca river is insufficient to provide water for year round irrigation of the potential agricultural land as noted in Chapter 3.3. It is necessary therefore to construct a storage system to regulate seasonal fluctuation of runoff. Some alternative dam and reservoir sites were examined along the mainstream of the Choluteca river, including:

Damsite	Drainage Area (km2)	Approximate Annual Runoff (MCM)
Zorillo	1,590	380
San Fernando	1,665	400
Oropoli	4,154	930
Morolica I	6,140	1,200
Morolica II	6,187	1,215

Through field investigation and study, the damsites at Oropoli and Morolica I were found to be topographically or geotechnically unsuitable for construction of a large dam. Construction of a dam at the Morolica II site was found to be technically possible, but its reservoir would inundate Morilica town and some villages located along the river. The valley is relatively wide at Morolica and construction of a fill-type dam would be more costly than at the San Fernando or Zorillo damsites upstream (See also Annex G.1.1).

The San Fernando damsite offers favorable topographic conditions. The valley forms a very narrow gorge with abutments rising at 70 - 80° from the river bed (EL. 740.0 m) to the terraces at around EL. 835 m. The topographic condition will permit construction of an arch or gravity type concrete dam. Geologically the damsite is composed of rhyolitic welded tuff. Vertical joints or joints of steep inclination are developed, and a fault line is assumed along the gully behind the terrace on the right bank. A core drilling revealed a thick bed of green altered tuff below the riverbed at a depth of between 9 m and 22 m. This should not be exposed by excavation because of its slaky nature. Its shear strength is low, or around 10 kg/cm^2. Such a low shear strength will make it difficult to design an arch type dam, but it may still be possible to design a gravity type dam by adjusting the dam section. Consequently, the San Fernando dam will be designed for the present to be a concrete gravity type dam. If as a result of in-situ rock tests, concrete dam is found to be unjustified, a fill-type dam would be designed at San Fernando or alternatively at Zorillo damsite (See also Annex D.2.1).

The available discharge at the San Fernando damsite (catchment area 1,665 km^2) was calculated from hydrological records at Hernando Lopez gauging station located approximately 2.5 km upstream of the damsite. The average annual runoff at the damsite for the past 29 years was 400.5 MCM (12.7 m^3/s). The discharge ranged from 4.6 MCM (1.7 m^3/s) in March - April to 88.0 MCM (34.0 m^3/s) in September (See Table 5-1). If the Guacerique dam is constructed by SANAA on the upstream tributary (catchment area 189 km^2) for water supply to the metropolitan area (1.18 m^3/s) and a return flow is assumed conservatively at 50%, the average annual runoff at the San Fernando damsite would be around 380 MCM (See also Annex G.1.2).

The potential gross storage capacity at the San Fernando damsite is estimated to be 450 MCM at EL. 826.5 m and 280 MCM at EL. 818.0 m. Since the sediment volume is estimated to be around 800 m^3/km^2/year or 1.33 million m^3/year, the effective storage will be about 210 MCM at EL. 818.0 m and 380 MCM at EL. 826.5 m.

5.2 Water Use for Irrigation

Potentially irrigable land in the Choluteca river basin (Choluteca plain and middle reach valleys) exceeds 30,000 ha in total. Since water to be stored by the San Fernando dam and reservoir is relatively limited, as reviewed in Chapter 5.1, the potential agricultural land discussed in Chapter IV must be given an order of priority for development for purposes of the reservoir operation study. After reviewing the socio-economic conditions in respective area, as well as the agricultural net returns estimated in Chapter 4.6, it is proposed that priorities in water allocation for irrigation should be in the following order (See Figure 5-1):

Priority	Area	
1 a	Western plain	16,000 ha
1 b	San Juan de Flores area	2,680 ha
1 c	Middle reach (existing)	680 ha
	(Sub-total)	(19,360 ha)
2 a	Eastern plain - A	4,600 ha
2 b	Eastern plain - B	5,200 ha
3	Middle reach (potential)	1,640 ha

Irrigation water requirement to be diverted at the intake weir is estimated by calculating potential evapotranspiration, crop consumptive use coefficient, consumptive use, effective rainfall and percolation for the various crops and cropping patterns as proposed in Chapter 4.4, allowing for irrigation efficiency. For irrigation on the Western plain, the diversion water requirement is estimated to be around 287.3 MCM per annum, with a maximum monthly requirement of 54.2 MCM (20.9 m^3/s) in April. Annual water requirements for the San Juan de Flores area and existing irrigation areas in the middle reach valley are estimated to be 28.4 MCM and 22.4 MCM, respectively. For the first priority irrigation areas (1a - 1c) of 19,360 ha, the annual diversion water requirement would amount to 338.1 MCM, of which 86% or 291.2 MCM would be required in the dry season from November to April (See Table 5-2, Figure 5-2 and Annex H.1).

Water requirements for the Eastern plain - A would be 87.4 MCM of which 72% or 63.0 MCM would be required in the dry season. If the Eastern plain - A is added to the first priority areas and a total of

23,960 ha is irrigated, the diversion water requirements would be increased to 425.5 MCM per annum, with a maximum requirement of 82.1 MCM/month (31.7 m^3/s) in April. To expand the irrigation area further to the Eastern plain - B, an additional 97.4 MCM would have to be diverted, and the maximum monthly diversion requirement in April would be 100.3 MCM (38.7 m3/s).

The above estimated diversion water requirements would have to be fed by the storage regulated at San Fernando and the natural outflow from the remaining basin downstream from the San Fernando dam. The storage requirement at San Fernando would depend upon reservoir operation.

5.3 Water Use for Power Generation

As briefly noted in Chapter 2.5, electric power supplies will be greatly improved with the completion of El Cajon hydroelectric project in 1985. Hydropower capacity will be increased to 423 MW, and some thermal plants are scheduled to be retired. It is noted, however, that the firm energy output of the existing and committed hydropower plants is limited to 1,624 GWh or 44% in terms of the average plant factor. This implies that the energy supply in the dry season from November to April is limited to 812 GWh. On the other hand, the energy demand is forecast to reach around 990 GWh in 1991. Consequently, thermal power plants will have to be operated to supplement the energy available during the dry season, even though the peak demand (344 MW in 1991) falls within the installed hydropower capacity. By the year 2000, power supply requirements in the dry season, primarily to cover base load, will be even greater (See Annex G.3.1).

Water stored in the San Fernando reservoir will be used primarily for irrigation, and irrigation water is mainly released in the dry season. Water released from the reservoir can be utilized to generate hydroelectric power with the head created by dam construction. At the San Fernando dam, therefore, it is planned to generate power constantly

(24 hours) in the dry season by water released for irrigation, and the generated power will cover a part of base load of the power demand, thereby saving energy to be generated by thermal plants. In the rainy season, on the other hand, inflow to the San Fernando dam would be stored to recover water released in the dry season. A small quantity of water (0.1 - 0.9 m^3/s) would be released even in the rainy season, to satisfy the water requirements of the San Juan de Flores area which is located immediately downstream from the San Fernando dam. This water release, small though it would be, could be utilized fro mini-hydropower generation for auxiliary power supply at the power station and dam operation, as well as for rural electrification. In a rainy year, some surplus water would be released in the rainy season through the turbines, and the generated power could cover a part of peak load of the power demand.

The capacity of water turbine is determined by the average water requirement for irrigation in April, when the water release is largest in the year, at any water level. It was calculated to be 21.9 m^3/s for irrigation over 19,360 ha and 32.2 m^3/s for irrigation over 23,960 ha. An average water level of the reservoir would be adopted as a rated water level to determine the rated output of generator. A water release valve would be installed to release irrigation water during the periods of scheduled and/or forced outage of the power plant (See also Annex G.3.2).

On the basis of the power generation plan outlined above, reservoir operation of the San Fernando dam would be conducted as described in Chapter 5.5.

5.4 Water Use for Municipal Water Supply

The demand for water in the metropolitan area is rapidly increasing, as briefly noted in Chapter 2.5, and a preliminarily study was required on the possibility of water being supplied from the San Fernando reservoir. Although detailed data and information was unavailable, a preliminary plan for water conveyance from San Fernando has been prepared and a preliminary estimate has been made of the water cost at Tegucigalpa (See also Annex G.4).

Water would be pumped from a low water level in the San Fernando reservoir (EL. 797 m). A site for intake pump station was provisionally selected near the Hombre river which is a major tributary of the Choluteca river. Although data are unavailable on water quality, it is likely that the water of the Hombre river will be much better in quality than that of the mainstream which contains untreated sewage from the Central District. In view of the average annual minimum discharge of the Hombre river (0.99 m^3/s) and the water supply of the Concepcion project (1.37 m^3/s) envisaged under SANAA's master plan, as well as in the light of possible effects on the reservoir operation of the San Fernando reservoir, it is provisionally assumed that 1.0 m^3/s would be taken at the intake pump station.

Water would be pumped in two steps. It would first be pumped to a pondage at EL. 1,030 m and then further boosted by No. 2 pump station to a delivery pondage at the treatment plant to be constructed near Tegucigalpa at EL. 1,105 m. A static head would be 312 m in total. The intake and booster pump stations would be equipped with 5 units of 15.0 m^3/min pumps. A pipeline of ductile iron pipe would be contracted along the existing highway to facilitate access for construction and maintenance. The economical diameter of the pipeline would be 1,100 mm, and the total length would be approximately 19.5 km. A 3.8 km long tunnel would be required in the final section near the treatment plant. The capacity of the treatment plant will be 87,000 m^3/day.

The investment cost for construction of the pumping stations, pipeline, treatment plant and electrical works, as well as for the replacement cost of some plant, is preliminary estimated to be about Lp. 120 million in total. The annual cost for operation and maintenance, as well as for amortization of the investment, is preliminary estimated to be Lp. 20.2 million in total. Since the volume of water supply is

31.5 million m3/year, the cost of treated water at Tegucigalpa is calculated to be approximately Lp. 0.72/m3. Since this is lower than other schemes contemplated under SANAA's master plan, it is considered to be worth further study in detail and inclusion of the water intake, for the time being, in the alternative case study of reservoir operation for the San Fernando reservoir.

5.5 Reservoir Operation

Reservoir operation was simulated as explained in detail in Annex G.5.2. With a view to the priorities for irrigation as noted in Chapter 5.2, alternative cases were simulated as follows:

Case 1-1: Irrigation of 19,360 ha (1st priority area), without intake for water supply

Case 1-2: Irrigation of 19,360 ha, with intake for water supply at 1.0 m3/s

Case 2-1: Irrigation of 23,960 ha (including Eastern plain - A), without intake for water supply

Case 2-2: Irrigation of 23,960 ha, with intake for water supply at 1.0 m3/s

Case 3 : Irrigation of 29,160 ha (including Eastern plain - B), without intake for water supply

As a result of reservoir operation, an effective storage capacity of 200 MCM would be required for irrigation of 19,360 ha without intake for water supply (Case 1-1). The calculated annual energy output would be 45 GWh, with an average power capacity of 7.1 MW in the dry season. If the intake for water supply is included at 1.0 m3/s (Case 1-2), the storage capacity would have to be slightly increased to 210 MCM and the annual energy output reduced to 43 GWh.

For irrigation of 23,960 ha in the first priority areas and the Eastern plain - A, the storage requirement would have to be increased to 354 MCM (Case 2-1). If the intake for water supply is included (Case 2-2), the storage requirement would be further increased to 380 MCM, with an annual energy output of 54 GWh, with an average power capacity of 11.1 MW in the dry season. The irrigation water releases are shown in Table 5-3.

Further, if the irrigation area is expanded to 29,160 ha (Case 3), the storage requirement would be 740 MCM. This requirement would be far above the annual inflow of around 400 MCM at San Fernando, and the storage capacity will not be recoverable. This alternative, therefore, is found to be technically unjustifiable (See Table 5-4).

5.6 Recommended Plan

Four alternative plans (Case 1-1, 1-2, 2-1 and 2-2) were preliminarily evaluated in terms of economic benefit/cost (B/C) ratio and benefit-cost (B-C) value. B/C ratio of Case 1-1 is estimated to be 1.20, while it is slightly decreased to 1.11 in Case 1-2. For irrigation of 23,960 ha and water supply at 1.0 m^3/s with an effective storage capacity of 380 MCM (Case 2-2), the B/C ratio is estimated to be 1.14. If the intake for water supply is unnecessary (Case 2-1), the ratio would be 1.24.

In addition to the preliminary economic evaluation as noted above, some other factors have to be taken into account in selection of the plan to be recommended. These are, among others:

a) Even if the water supply intake is not immediately to be provided directly from the San Fernando reservoir, water may possibly be taken from other place in the catchment area. It is therefore recommended that the storage capacity should be planned at this moment to cover water supply,

b) Opportunities for water storage in the middle reach valleys are relatively limited and would be much higher in cost. It is therefore desirable to store as much water as possible at San Fernando and to expand the irrigation area in the Choluteca plain, and

c) Stage-wise development is desirable, but dam heightening in stages would be difficult in practice and uneconomical. It is recommended therefore that the San Fernando dam be constructed at the initial stage at the height designed for the ultimate stage of development.

In view of the above, it is recommended that the San Fernando dam be designed to have an effective storage capacity of 380 MCM for irrigation of 23,960 ha and power generation of 54 GWh. The result of reservoir operation under the selected case 2-2 is illustrated in Figure 5-3.

VI. PROPOSED PROJECT FACILITIES

6.1 San Fernando Dam

It has been recommended that a dam be constracted at San Fernando to secure 380 MCM of effective storage capacity for irrigation of 23,960 ha. The effective storage capacity would be secured between a low water level of EL. 797.0 m and a high water level of EL. 826.5 m. Dead storage capacity below low water level will be 67 MCM, which has been determined on the basis of sediment inflow estimated at 800 $m^3/km^2/$ year. A surcharge of 100 MCM would be provided between the high water level and a flood water surface at EL. 833.0 m for passage of the probable maximum flood, which would provid a measure of flood control by the reservoir. The area flooded by the reservoir would be approximately 23.5 km^2 at the flood water surface.

As noted in Chapter 5.1, the San Fernando dam will be designed for the present as a concrete gravity type dam. The dam crest is set at EL. 835.0 m, or 2.0 m above the flood water surface and almost at the same elevation as the terraces on both abutments of the damsite. The dam will be 100 m in height from the foundation and 320.0 m in crest length. A stability analysis for design of dam has been made, by taking into account an assumed coefficient of earthquake acceleration of 0.16 g and a shear strength of 10 kg/cm^2, as noted in Annex D.2.1. The upstream face of the dam will slope at 1 : 0.15 with a fillet of 1 : 0.8 in slope below EL. 775.0 m. The downstream slope will be 1 : 0.8. In view of the low shear strength, an apron of 20 m in height will be provided on both faces of the dam. A crest road will have a width of 8.0 m. A general plan and section of the proposed dam is shown on DWG-01 to DWG-03.

The probable maximum flood is estimated to be 5,300 m^3/s in peak discharge and 511 MCM in volume. The peak discharge would be reduced to 3,380 m^3/s by routing in the surcharge space between EL. 826.5 m and EL. 833.0 m. A spillway with a capacity of the reduced discharge will be provided in the center of the dam in line with the river course. Three sets of radial gates (8 m x 10 m) will be installed on the ogee crest at EL. 819.0 m. The gates will be operated by motor-driven hoists which will be installed on the top of the concrete piers. The upper portion of spillway chute will be the downstream face of the dam, guided by concrete side walls. The lower part of spillway chute will be an upturned flip bucket. A plunge pool of 70 m in length will be provided below the flip bucket, with concrete protected on the bottom and sides. A concrete sub-dam of ogee type (40 m in length and 7.5 m in height) will be constructed at the end of plunge pool.

A concrete lined diversion tunnel of 6.0 m in diameter will be excavated for a length of 340 m in the right abutment. The upstream cofferdam of 20 m in height from foundation will be constructed as a concrete structure and it will serve as a part of dam apron concrete. The diversion system will discharge 270 m^3/s, so that foundation excavation, consolidation grouting and concreting can be carried out during 6 months of the dry season (See DWG-04).

An intake for turbines and river outlet will be a steel lined bellmouth at the upstream face of the dam, with its bottom elevation at EL. 786.0 m. A fixed trash rack and a roller gate of 8.5 m in height and 3.5 m in diameter will be embedded in the dam between the intake and power station. The maximum discharge in the penstock will be 32.3 m^3/s.

The power station will be located at the toe of the dam. It will be a concrete structure of 30 m in width, 44.8 m in length and 19 m in height. Two sets of generators with vertical shaft Francis turbines will be installed, with a rated head of 67.5 m and a maximum discharge of 16.1 m^3/s for each turbine. The installed capacity will be 18.2 MW in total, with an annual energy output of about 53.6 GWh. In addition, a mini-hydropower plant of 500 kW will be installed to utilize water to be released for irrigation in the San Juan de Flores area during the wet season. A jet flow gate and guard gate will be installed to release irrigation water during the period of scheduled and/or forced outage of the power plants. One set of steel stoplogs will be installed at the end of draft tubes. The normal tail-water level will be EL. 745.0 m for the maximum discharge of 32.2 m^3/s. The tailbay will be located between the power station and plunge pool. A 25 km single circuit 60 kV transmission line will be constructed between the power station and Tegucigalpa sub-station (See DWG-05).

Part of the highway between Tegucigalpa and Talanga will be flooded by the proposed reservoir, and road relocation will be required along the western edge of the San Fernando reservoir. The highway relocation will be 8 km in length, and it will be constructed to the same design criteria as the existing highway. Further, the old road to Olancho through Hernando Lopez bridge will also be flooded, but it can be relocated by making use of the access road to be constructed for the project.

6.2 Intake Weir

Irrigation on the Western plain (16,000 ha) will be effected during the first stage of implementation. For irrigation on the Western plain, an intake weir would be constructed at a site near El Papalon about 9 km downstream from Choluteca. The catchment area at El Papalon is 7,115 km^2. The river channel is approximately 100 m in width, and the river bed elevation is EL. 20.5 m. The river deposits are underlain by weathered andesite at 9.4 m in depth and solid andesite at 13.1 m in depth.

The intake weir is designed to be an ogee crest concrete type weir of floating foundation to avoid deep excavation. The weir will be 4.8 m in height, 140 m in crest length and about 15,000 m^3 in volume. The ogee crest is 125 m in length at EL. 23.8 m. Two lines of steel sheet pile cutoff walls will be provided between the base of the weir and bed rock. A concrete apron blanket with dental sills and cutoff will be provided on the downstream side of the weir. The upstream concrete blanket will be 10 m in width. A scouring sluice with 3 sluice gates (3.5 m x 3.0 m) will be provided. A scouring trough, 12 m in width and 45 m in length with concrete bottom and side walls upstream of the sluice, will maintain a low water channel at the right side of the pondage. The pondage water surface will be at EL. 28.4 m for the design flood discharge estimated at 2,600 m^3/s for the return period of 100 years. The pondage will normally be confined within the existing river channel, but 1.5 m high levees will be constructed on both banks of the river upstream of El Papalon weir (See DWG-06 and Annex H.4.2).

The intake structure will be located on the right bank, just upstream of the scouring sluice section of the weir. The inlet bay will be a rectangular concrete open channel of 29 to 12 m in width, with the bottom elevation at EL. 22.3 m. Three sets of roller gates (2.0 m x 3.0 m) will be installed for closure at the end of the inlet bay. A desilting basin of 20 m in width and 90 m in length, and equipped with a sand flush channel, will also be provided. Two sets of stoplogs will be installed at the end of desilting basin at the head of the main canal for irrigation of the Western plain.

6.3 Canal Systems in Western Plain

A layout of the irrigation and drainage canal systems has been prepared for the net irrigation area of 11,970 ha, excluding the area of existing irrigation systems (4,030 ha) which will be supplied from the project (See DWG-07 and Annex H.4).

The main irrigation canal system will consist of the upper main canal, left main canal and right main canal. The upper main irrigation canal will be connected to the desilting basin at intake weir, and will run for 11.6 km on the right bank of the Choluteca river. Three secondary irrigation canals will branch off from the upper main canal to distribute water to Ola district. The upper main canal will bifurcat into the left main canal and right main canal at Los Llanos. The left main canal (9.8 km in length) will follow the Choluteca river so as to function at the same time as a flood protection dike. The left branch canal will further extend across the Choluteca river by inverted siphon for irrigation of 3,600 ha on the left bank of the river. The left main canal and left branch canal will have three secondary canals with a total length of about 12.6 km, while the right main irrigation canal will run for about 3.5 km along the western bank of the old river channel. Four branch canals will extend for about 40 km in total, to irrigate the right bank of the Choluteca river, together with 21 km of secondary irrigation canals.

The main irrigation canals are designed to be trapezoidal open channels with side slopes of 1 : 1.5 and lined with concrete of 10 cm in thickness. The design flow velocity will be between 0.5 m/s and 1.5 m/s. The branch irrigation canals are also designed to be concrete lined trapezoidal open channels with side slopes of 1 : 1.5 to 1 : 1.0. The design flow velocity of the branch canal will not exceed 0.6 m/s (See DWG-08).

The branch and secondary irrigation canals are aligned to run in parallel with existing distributaries and depressions which, it is proposed, should be improved and function as drainage canals. The old river course, for instance, will be improved and utilized as the right main drain No. 2. The right main drain No. 1 and No. 3 will also be aligned along the existing depressions. Improvement of the distributaries and depressions will be made by deepening and enlarging the channels to provide for the design drainage requirements estimated to be approximately 5.3 lit/s/ha in the Choluteca plain.

The main farm roads will be constructed along the main and branch irrigation canals. They will be designed as gravel-metaled roads of 6.0 m in effective width. Secondary farm roads, unpaved and 3.4 m in width, will be constructed along the secondary irrigation canals.

6.4 Canal Systems in Eastern Plain - A

Irrigation in the Eastern plain - A (4,600 ha) located on the relatively flat terraces on the left bank of the Choluteca river, will be implemented during the second stage of the project implementation. For irrigation in this area, two alternative intake weir sites are conceived; one is located at Las Bases about 5 km upstream of Choluteca, and the other is located at about 2 km downstream from Choluteca. The downstream weir site is preferable if irrigation is to be limited to the Eastern plain - A, while the alternative site at Las Bases should be considered if and when the Eastern plain - B is contemplated in future for irrigation by stored water additional to that from San Fernando.

Water diverted at the weir site will be led to the main canal system to the south of Choluteca city. (If the weir is to be located at Las Bases, an additional headreach canal of 7.7 km in length will be required.) The main irrigation canal will follow the right bank of the Sampile river for 3.8 km before bifurcating into branch canal EB-1 (9.3 km) to run further along the Sampile river and branch canal EB-2 (8.9 km) to extend to the southwest. Another branch irrigation canal (EB-3 in 12.1 km) will be aligned to the west of EB-2 canal. The main drainage canals (ED-1 and ED-2) will run in parallel with the branch irrigation canals (EB-2 and EB-3). The drainage canal ED-3 will form a border with the Eastern plain - B. Design of canals will follow the same design criteria as proposed for the Western plain systems (See DWG-09).

6.5 On-Farm Facilities

As a result of comparative study, it is recommended that, furrow irrigation should be applied in principle to cultivation of sugar cane and other upland crops and flood irrigation for paddy cultivation. From a study of the soil-water characteristics of the Choluteca plain, a standard furrow length of 200 m is proposed for design of irrigation systems (See also Annex H.2). Further, in view of the topographic conditions in the Western plain and Eastern plain - A, tertiary irrigation canals and collector drains will generally be aligned to run at intervals of about 1.0 km to distribute water to the field canals and to drain excess water from the field.

Thus farm blocks of 200 m x 1,000 m will be formed, which will be divided into four farm lots of 5 ha each. Irrigation water will be diverted from the tertiary canal to the field canals, and further distributed to farm ditches. Drained water will be collected in the farm drains and conveyed to the collector drains which will be generally aligned in parallel with the tertiary irrigation canals. The canal length of the tertiary canals will be around 152 km in the Western plain and 51 km in the Eastern plain-A. Tertiary roads will also be constructed along the tertiary irrigation canals (See DWG-10).

Facilities related to the irrigation and drainage systems will include turnouts, cross regulators, drops, culverts, drainage culverts, spillways, bridges and division boxes. The capacity and size of these facilities will vary in accordance with the irrigation intervals and kind of crops to be cultivated in each field. A total of 770 turnouts and 3,080 division boxes in the Western plain and 225 turnouts and 1,020 division boxes in the Eastern plain-A will be provided for on-farm development.

Day-to-day measurement of water is required to monitor daily water use and to compare it will inflow, reserves and demand. Accurate and reliable measurement is essential for efficient use of water and as a basis for charges to water uses. At the turnouts of every tertiary canal, a constant head orifice gate type water measuring device will be installed, in addition to parshall flumes to be installed at the turnouts of main, branch and secondary canals.

Land clearance will be mechanized, except for removal of small stones. Minor levelling will be required for upland crop fields, and more precise levelling for paddy fields. Land levelling will be executed in accordance with the contour lines. At the final stage of land preparation, the fields will be plowed to a depth of about 0.5 m as an initial plowing.

VII. CONSTRUCTION SCHEDULE AND ORGANIZATION

7.1 Construction Schedule

The schedule for construction of the San Fernando dam and irrigation systems on the Choluteca plain has been prepared on the basis of the following considerations:

a) Implementation of the San Fernando dam and irrigation in the western plain (16,000 ha) will be scheduled in the first stage. Expansion of irrigation and drainage systems to the Eastern plain - A will be implemented in the second stage. Construction of facilities planned for the first stage will be scheduled to be completed at the earliest possible date in the most economical manner.

b) Detailed design and tender documents will be prepared as soon as possible. Detailed design is therefore scheduled to start soon after completion of the feasibility study, or in early 1985.

c) Contractors for construction works will be selected through international competitive bidding. The period required for tendering, evaluation and award of contracts will be at least 7 months.

d) Construction work will be scheduled in the light of physical conditions in and around the work sites, including topographic and climate conditions. Workable days per annum are assumed to be 210 days for common excavation, 270 days for rock excavation and 250 days for concrete works, on the basis of meteorological data. Working hours will be 7 actual hours per shift. A two shift system will be adopted for tunnel works.

The construction contract for the San Fernando dam is scheduled to be put out to tender in October 1986 for award in April 1987. Construction works would commence in July 1987. River diversion would be completed in the dry season in early 1988. Dam concrete works and diversion closure will be completed by the end of 1990. If a roller compacted dam construction method is applied, dam construction may possibly be completed about 5 months ahead of a gravity dam construction by the conventional method. Installation of electro-mechanical works is provisionally scheduled for contract award by October 1987, and manufacture and installation in 1988-90. The power plants may possibly be commissioned by the end of 1990.

The irrigation and drainage systems in the Western plain will be constructed by dividing the area into three blocks. Tenders for construction are scheduled to be called at the beginning of 1987, and construction work on the intake weir will be completed in two dry seasons or by the end of the rainy season in 1989. Construction of the first block of irrigation may possibly be completed by the end of 1988. Construction of the second block may also be started by the beginning of 1987-88 dry season and will be completed by early 1990, or a few months after completion of the intake weir. The third block may possibly be constructed in two dry seasons in 1989-91.

Implementation of the irrigation and drainage system on the Eastern plain - A (4,600 ha) will be scheduled for the second stage. It is provisionally scheduled that construction works will be started in middle of 1991, after completion of construction in the Western plain and under separate financial arrangements to those for construction of the San Fernando dam and the Western plain irrigation systems.

A tentative construction schedule is illustrated in Figure 7-1.

7.2 Organization during Construction

MRN will be the executing agency for construction of the project. However, the cooperation of other institutions such as INA, ENEE, SECOPT, BANADESA, Catastro Nacional, etc. will be indispensable for the successful implementation of the project. An alternative arrangement would be to set up a public corporation for construction, operation and maintenance of projects to be executed in the Choluteca river basin in view of the coordination required among various institutions for multi-purpose development. However, in view of the fact that the San Farnando dam will be constructed and operated primarily for irrigation, it is proposed that there should be a simple agency for execution of the project. MRN, through the Directorate General of Water Resources, would therefore be responsible for administration of pre-construction and construction works. MRN will be the end user of foreign loans.

MRN will appoint a project director, positioned directly under the Director General of Water Resources, to coordinate the execution of the project. A consulting team, or a foreign consulting firm in association with local consultants, will be employed by MRN to assist the activities of the project director. Two construction offices will be established at San Fernando and Choluteca. The function of each office will involve approval of construction methods and schedules, preparation of revised design, coordination among contracted works, monitoring of the construction progress, work quantities and quality control, approval of payments and completion of works, etc. MRN will designate resident managers in each construction office. The Resident Managers will superintend the works assigned to each office and report to the project director, in collaboration with the consulting team. MRN may also assign an appropriate number of counterpart staff who will jointly work with and trained by the consulting team. During the period of installation of equipment, staff to be assigned for operation and maintenance of these equipment will also be appointed as counterparts. The organization of the construction offices is illustrated in Figure 7-2.

INA will be responsible for the expropriation of land, entitling and training for resettlement program to be executed in accordance with the Agrarian Reform Law. After preparing detailed program for resettlement in the project area, INA will promote settlement, organization of cooperatives and their consolidation. The cooperation of Catastro Nacional will be sought for land valuation.

MRN will make arrangement with ENEE for pricing and the operation rule of the San Fernando power station. ENEE will cooperate in construction of the power station, transmission line and substation. SECOPT will also cooperate in highway relocation.

BANADESA will cooperate in management of credits to be extended to farmers, cooperatives and resettlement groups for on-farm construction. New credit systems and conditions will have to be established in consultation with MRN and the financing institution.

7.3 Organization for Operation and Maintenance

The project facilities will be state properties. MRN will continue to be responsible for the operation and maintenance of the project. The two construction offices will be turned over to the San Fernando Dam Management Office and Choluteca Water Management Office, upon completion of the project.

The San Fernando Dam Management Office will undertake the operation and maintenance of reservoir and dam, as well as supervise the operation of the power station. Scheduled water releases for irrigation will be advised to ENEE well in advance. Operation and maintenance crews of the power plants may possibly be designated by ENEE. Equipped with radio telecommunication systems, the San Fernando Office will maintain close communication with the Choluteca Water Management Office. The Choluteca Office, on the other hand, will be responsible for operation and maintenance of irrigation and drainage systems. The office will also be responsible for assessment and collection of water charges, as well as measurement of macro- and micro-climate, soil moisture, etc. (See Figure 7-3).

MRN regional office in Choluteca, as well as the experimental station and training center in La Lujosa, will be strengthened to provide adequate extension services and execute systematic researches and training. For training in irrigation practices, including water application and management, La Lujosa training center will maintain close coordination with the Agricultural Development Training Center (CEDA) of MRN in Comayagua, as noted in Chapter 4.5.

INA will organize the farmers into cooperatives. It is estimated that about 2,400 farmers (1,750 in the Western plain and 650 in Eastern plain-A) may be settled, in addition to the 280 members of the existing cooperatives. The cooperatives will be organized on such a scale that the irrigation systems will be smoothly managed and large items of machineries can be jointly operated. They will maintain close communication with the Choluteca Water Management Office, as well as regional offices of INA, MRN, BANADESA, IHMA, etc. It is suggested that small farmers should also be organized into several water users' association for efficient water management.

7.4 Water Regulation

The water law in Honduras was enacted in 1929, and is today quite obsolete. In practice, there are no existing water rights, and no water charges are collected in the Choluteca river basin. MRN has already prepared a draft of new regulations with technical assistance of FAO, and these are currently under review before presentation to the congress.

For successful implementation of an irrigation project on such a large scale as proposed for the Choluteca plain, it is considered to be essential that the new water law or regulations should have been promulgated. It is also necessary to define water charges under the regulation and to help the farmers to understand the regulation and proposed charges. It is recommended therefore that the water regulations be promulgated as soon as possible.

VIII. ENVIRONMENTAL ASPECTS

8.1 Environmental Condition

Environmental conditions in the area directly related to the project, as well as measures being taken by the authorities concerned for their protection, are briefly reviewed here.

1) Watershed Area:

Watershed of the Choluteca river, particularly in the basin upstream of the San Fernando dam, has much effect on the proposed dam and reservoir. For instance, deterioration in the watershed will further increase sediment transport and shorten economic life of the dam, and it will increase flood magnitude and decrease firm river discharge. For water management in the Choluteca river basin, MRN has been executing the National Resources Management Project (PMRN) since 1980. The project incorporates such programs as soil and water conservation in the sloped area, reforestation to recuperate watershed, management of pasture land, and promotion of training and community development in the watershed areas. Five sub-basins were selected, including the upper-most sub-basin upstream of Tegucigalpa (606 km^2), and programs are being executed with a fund of about Lp. 44 million. In the upper-most sub-basin, nearly 77% of the land has gradient over 15°, and about 30% of land is presently used for pasture land, agricultural land and population centers. Urbanization is sprawling by scooping the sloped land. PMRN programs are, in no about, of vital significance for the development of water resources, and their successful achievement is expected. For the implementation of the Choluteca dam and irrigation project, it is desirable that the PMRN programs will be expanded to cover the rest of catchment area up to the San Fernando damsite (See also Annex B.3.2).

2) Water Quality:

The quality of water for irrigation use was checked in the lower Choluteca river basin and San Juan de Flores valley. The pH value was around 7.0 - 7.8, and electric conductivity below 1,000 V/cm in most cases, except for water in the coastal zone where salinization was observed. Water quality is thus satisfactory and will not adversely affect crop growth and production.

There is some contamination of water in the upstream reaches, due to ingress of untreated sewage from the metropolitan area. Since there are at present no sewage treatment facilities in the Central District nor legislative regulations to control sewage and effluents from industrial plants, chemical and biological contamination will increase unless appropriate measures are taken by the authorities concerned. Although water from the San Fernando reservoir at the outlet of the Hombre river has been studied preliminarily, it is necessary to investigate carefully the quality of water in the Hombre river, as well as water of the mainstream at the confluence with the Hombre river. In any case, establishment of further industries in Zambrano valley or in the catchment area of the Hombre river, will have to be regulated so as not to contaminate river water.

3) Landslides:

The relatively high yield of sediment in the Choluteca river (about 800 m^3/km^2/year) is caused principally by erosion in deforested land and landslides. The landslides have been observed in areas with steep slopes, particularly in places where roads and other structures have been constructed. In road construction, for instance, there are unprotected steep slopes, cuttings and spoil banks which yield a large volume of sediment.

4) Others:

No notable wild animals or plants have been observed in areas affected by the project. Some fish species are found in the upstream reaches, but there is no reason to believe that the reservoir will materially affect their beology. No information has been discovered in respect of archaeological ruins in the area to be flooded by construction of the San Fernando reservoir.

8.2 Environmental Impacts

Construction of the San Fernando dam and irrigation systems, as well as the practice of the proposed irrigated farming will have some environmental effects or impacts. The main impacts may be summarized as follows:

1) Effect of Flood Control:

As noted in Chapter 6.1, the San Fernando reservoir will regulate and reduce floods downstream. It is estimated that the probable maximum flood will be reduced from 5,300 m^3/s at present to around 3,380 m^3/s by the San Fernando dam. Although the catchment area at San Fernando accounts for only about 24% of the drainage area at Choluteca, this regulation will contribute to mitigation of inundation which occurs frequently in the lower Choluteca plain. Further flood control will be provided by construction of canal embankments along the Choluteca river to function as flood protection dikes.

2) Impoundment in Reservoir:

The San Fernando reservoir will be created in a wide open valley with gently sloping topography composed of massive Tertiary tuff. In impounding the reservoir, there will be no problems of leakage through thin ridges or porous bed rocks. There will be no dangers of large scale land slides or collapse of slopes in the wide open valley developed along the reservoir area.

3) Land Affected by Reservoir:

About 2,350 ha of land will be submerged by construction of the San Fernando reservoir. There is no village of significant scale in the reservoir area. Only about 600 ha of seasonally cultivated and pasture land will be affected, the remaining areas being non-cultivated land, water surface, river beaches, etc. The production forgone in the reservoir area will be limited in economic terms. Less than 100 families living in the reservoir area will require resettlement.

4) Irrigation Application:

Inappropriate irrigation application, as well as deep plowing by machinery, may cause soil erosion. To prevent such a soil erosion, contour irrigation has been recommended, particularly in the paddy fields. Appropriate water management will also be important to avoid such erosion. The drainage system to be improved will be effective in leaching the slightly salinized soils in the coastal zone. Since irrigated agriculture is already being practised to some extent on the Choluteca plain, there will be no drastic change in environment even after irrigation is applied more extensively.

5) Chemical Applications:

Fertilizer and chemical application could have adverse effect on environment. To prevent contamination of water and soil organisms, application of poisonous chemicals should be avoided as far as possible.

6) Soil Conservation:

Monoculture for a long period will have adverse effects on soil organisms. It may also cause occurrence of pests and decrease in soil fertility. The rotational cropping proposed for the Choluteca plain will be preventive of such a deterioration. Introduction of bean cultivation as a rotational crop will be particularly effective for soil conservation.

IX. ESTIMATED COST

9.1 Basis of Estimate

The construction cost of the dam and irrigation systems was estimated on the basis of work quantities measured from the preliminary design and unit prices estimated for each item of works. All costs are estimated in Lempira at mid-1984 prices. The construction works will be let to contractors to be selected by international competitive tenders, except for minor construction works to be let to local tenderers.

The construction cost was estimated to cover such direct costs as labor, materials and equipment, as well as indirect costs such as contractors' overhead costs and profit. The cost of imported materials and equipment was estimated on the basis of CIF San Lorenzo and inland transportation costs, exclusive of import duties and taxes which may be exempted as in the case of other construction projects executed by the government and public institutions. Engineering and administration costs were also estimated to cover the costs of detailed investigations, preparation of design and tender documents, as well as for supervision of the construction works. Physical contingencies were estimated to be 10% of direct construction costs to cover such unknown factors as changes in work quantities, in geological conditions and accuracy in topographic maps, etc. Price contingencies to cover price escalation were estimated to be 6% for costs to be incurred in local currency and 5% in foreign currency. The locally available labor, materials and services were estimated in terms of local currency and imported materials, equipment and services in terms of foreign currency.

9.2 Investment Cost

The investment costs for construction of the San Fernando dam and irrigation systems on the Choluteca plain were estimated as given in Table 9-1 to 9-4, and as summarized below:

		Investment Cost (Lp. 10^3)		
		Foreign Currency	Local Currency	Total
1)	San Fernando dam:	65,277	24,740	90,017
2)	Power station:	12,774	2,719	15,493
3)	Irrigation:			
	Western (16,000 ha)	63,981	19,297	83,278
	Eastern - A (4,600 ha)	24,891	7,021	31,912
4)	Associated irrigation:			
	S.J. Flores & Middle Reach (3,360 ha)	4,900	1,062	5,962
5)	Land Compensation, Engineering and adm.	17,640	17,607	35,247
6)	Physical and price contingencies:	80,025	34,903	114,928
	Total:			
	Dam/power + 23,960 ha	269,488	107,349	376,837
	Dam/power + 20,600 ha	263,559	106,062	369,621
	Dam/power + 16,000 ha	218,170	84,633	302,803

Details of the construction investment costs are presented in Annex J.1.2.

9.3 Disbursement

The annual disbursement of construction investment cost was estimated in relation to the construction schedule proposed in Chapter 7.1, for the stages of development as noted in Table 9-5 to 9-7. For example, disbursement of the construction cost for the San Fernando dam and first stage irrigation over 16,000 ha would be as follows:

	Disbursement Schedule (Lp. 10^6)							
	1985	1986	1987	1988	1989	1990	1991	Total
Foreign currency	5.6	3.7	20.0	58.0	71.2	53.6	6.0	218.1
Local currency	2.0	2.0	10.9	22.6	26.3	18.2	2.7	84.7
Total	7.6	5.7	30.9	80.6	97.5	71.8	8.7	302.8

X. ECONOMIC EVALUATION

10.1 Economic Cost

The economic construction cost was estimated by deducting such transfer payments as taxes and by applying shadow wage rates and shadow exchange rates, to evaluate the project in terms of the national economy. Taxes imposed on local procurement and shadow wage rates for unskilled labors were estimated to amount to approximately 5% of the investment costs to be incurred in local currency. A shadow exchange rate of Lp. 2.5 per dollar was applied to costs estimated in foreign currency.

Although the San Fernando dam is designed and its investment cost has been estimated to secure storage for water supply to the metropolitan area, such a water supply system is to be economically evaluated separately. In this study, therefore, the costs to be incurred in heightening the dam by 1.5 m for water supply are considered to be allocated to the water supply project and the economic cost of the San Fernando dam for irrigation and power generation is estimated for a dam of 98.5 m in height.

The total economic cost of the San Fernando dam and Choluteca irrigation (23,960 ha) is estimated to be Lp. 330.1 million. If irrigation is implemented to the first stage of 19,360 ha, the economic cost will amount to Lp. 283.6 million.

The annual operation and maintenance costs to cover the cost of staff, regular maintenance and minor repairs, were estimated to be 0.2% of the San Fernando dam and power facility and 2.0% of the cost of the irrigation facilities. Likewise, the replacement costs of electrical and metal works were estimated to incur after expiry of their useful life. A salvage value of about 10% was assumed in estimating the replacement cost.

Disbursement schedules of investment cost, in terms of the annual economic cost of the project, are summarized in Table 10-1 to Table 10-3, for each scale of development (See also Annex J.2.1).

10.2 Economic Benefit

The economic benefits accrue directly from increased agricultural production and electric power generation. The benefits have been estimated as follows:

1) Agricultural Benefits:

The agricultural benefits were estimated in terms of incremental benefits by comparison of "with" and "without" project conditions. For the economic evaluation, economic prices of farm inputs and products have been estimated by referring to the IBRD price forecasts, at 1984 constant prices. For estimates of economic costs of production, shadow exchange rates and shadow wage rates have again been applied. The economic net return was first estimated for each crop and then for each area in accordance with the proposed cropping area. Through development of the Western plain (16,000 ha), it is expected that the net incremental benefit will amount to Lp. 39.9 million. Likewise, development in the Eastern plain - A (4,600 ha) will bring about a net return of Lp. 14.6 million (See Table 10-4 and 10-5).

Benefits from the development in the middle reach valleys (2,680 ha in San Juan de Flores and 680 ha in other existing areas) for which water would be stored and secured by the San Fernando dam, were also estimated as an associated benefit of the project. The net incremental benefit will amount to Lp. 5.7 million (See Table 10-6). Consequently, the agricultural benefit annually accruable from the project was estimated to be approximately Lp. 60.2 million at full scale development (23,960 ha) and Lp. 45.6 million in the first stage development (19,360 ha). The said benefits will be attained after a build-up period of 5 years. Production foregone in the area flooded by the San Fernando dam and reservoir was estimated as a negative benefit (See also Annex J.2.2).

2) Power Benefits:

Power will be generated by making use of water released for irrigation, and the generated power will, in principle, be used to cover the base load. Although the installed capacity will be 18.2 MW, power generation in the dry season will fluctuate in accordance with the irrigation water releases. Consequently, the average capacity from December to April (11.1 MW) was taken in evaluating the capacity value of the alternative power source which would be an oil-fired thermal plant. Although some peak power will be generated by surplus water in a rainy year, such peak power generation will be uncertain and has not been included in the economic evaluation. The fixed operation and maintenance value was estimated to be Lp. 0.57 million per annum.

The energy value of the alternative oil-fired plant was estimated on the basis of prevailing fuel costs. The energy value was thus estimated to be Lp. 0.1311/kWh, or Lp. 7.0 million per annum. The variable operation and maintenance value was estimated to be Lp. 0.54 million per annum. Further, replacement costs of thermal plants would be incurred after their service life of 25 years (See also Annex J.2.2).

Economic benefits, both agricultural and power, were estimated for the evaluation period of 50 years, as summarized in Table 10-7 to 10-9. The annual economic benefits of the project in an ordinary year will amount to Lp. 68.0 million at full scale development and Lp. 53.3 million in the first stage development.

10.3 Economic Internal Rate of Return

The economic internal rate of return (EIRR) was calculated to evaluate economic feasibility of the proposed project, on the basis of the economic costs and benefits estimated in Chapter 10.1 and 10.2, as summarized below:

	EIRR (%)
Dam and irrigation of 23,960 ha	14.2
Dam and irrigation of 19,360 ha	13.7

From EIRR calculated above, it may be seen that the implementation of the proposed dam and irrigation project to the ultimate stage (i.e. full scale development) is economically feasible. Implementation of the first stage development may also be considered to be economically justifiable since the opportunity cost of capital investment in Honduras will be at least 12%.

A sensitivity analysis was made by assuming some changes in variables. It will be seen that the EIRR is less sensitive to an increase in costs, though slightly as it is, than to a decrease in benefits. EIRR will fall to 13.2% for irrigation of 23,960 ha and to 12.6% for irrigation of 19,360 ha, if costs increase by 10%. EIRR will fall to 13.1% for irrigation of 23,960 ha and to 12.5% for irrigation of 19,360 ha, if benefits accruable from the project decrease by 10%. Even then, EIRR would be well over the least opportunity cost of capital in Honduras (See Table 10-10, Figure 10-1 and Annex J.2.3).

10.4 Unquantified Benefits

Although EIRR has been calculated for irrigation and power benefits, the feasibility and the importance of the project will be further supported by such unquantifiable benefits as described below:

a) Storage for the metropolitan water supply has not been economically evaluated in this study, because of the preliminary stage. However, if water is pumped up from the San Fernando reservoir, the economically allocated cost for dam heightening by 1.5 m is very small or less than Lp. 1.0 million, yet it will benefit the water supply scheme significantly.

b) The San Fernando dam will regulate the flow of the Choluteca river, which will alleviate inundation in the lower river basin. As noted in Chapter 8.2, the probable maximum flood at San Fernando will be reduced from 5,300 m^3/s to 3,380 m^3/s by the dam. Although the flood control effects downstream have not been quantified, they will be substantial and will increase the economic benefits of the San Fernando dam.