NARIVA SWAMP
DEVELOPMENT PROJECT
TRINIDAD AND TOBAGO

FEASIBILITY REPORT

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

GENERAL CONTENTS

Preface

The Government of Trinidad and Tobago, with the view to developing the Nariva Swamp Area of Trinidad Island into the farm lands for the increase in food production, requested the Government of Japan for cooperation in the survey of the Nariva Swamp Development Project through the Japanese Economic Mission which visited the country in January 1965.

In response to this request, the Government of Japan decided to carry out a reconnaissance survey and entrusted the Overseas Technical Cooperation Agency with its execution.

In September 1966, the Agency sent a reconnaissance survey team composed of three experts headed by Mr. Kensaku Takeda, Deputy Chief, Designing Division, Agricultural Land Bureau, Ministry of Agriculture and Forestry. The team carried out survey on the existing state of the Nariva Swamp Area and collected various data and reference materials during the one-month field survey and presented a report in Feb. 1967.

In January 1968, the Government of Trinidad and Tobago requested the Government of Japan again for cooperation in early execution of the feasibility study of the project. In December 1968, the Agency was entrusted by the Government of Japan with the execution of the feasibility survey and despatched a survey team of eleven experts led by Mr. Kensaku Takeda for a period of about 50 days from March 1969.

Following this field survey, the team carried out, for almost six months after returning to Japan, the home office works. The outcome of these studies and works is incorporated into the feasibility report on the Nariva Swamp Development Project which is presented herewith.

Should this report contribute to the promotion of friendly relations and economic interchange between our two countries as well as to the realization of the Nariva Swamp Development Project, nothing would be more gratifying for us.

On this occasion, we should like to express our deepest gratitude for the support and cooperation rendered by the Government of Trinidad and Tobago, the University of the West Indies and other relevant organizations.

Keiichi Tatsuke
Director General
The Overseas Technical Cooperation Agency
Tokyo, Japan

Letter of Transmittal

March, 1970

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir:

I have the honour to inform you that the survey team for the Nariva Swamp Development Project in Trinidad and Tobago has successfully completed its mission and am pleased to present herewith the feasibility report.

The survey team carried out the field works for about 50 days from the middle of March 1969 with respect to the technical and economic aspects of the project with the close cooperation of the Government of Trinidad and Tobago. The field survey included topographical survey, coastal survey, soil survey, hydraulic and hydrological survey in the project area, and furthermore, collection of necessary data, estimation of construction cost and agro-economical study.

After returning to Japan, the team devoted itself to preparation of the report based on feasibility study including data analyses, cost calculation, economic evaluation as well as preliminary design of the required structure.

The Nariva Swamp Development Project aims mainly at the agricultural development by utilization of land and water resources in the Nariva area extending in the central part of the eastern coastal area of Trinidad Island.

At present, most of Nariva Swamp area is left unutilized, and it is the water that hinders the development of the area. In consideration of the rainfall pattern in the project area, drainage in the wet season and irrigation in the dry season shall be taken up as the essential problems in this project.

In the proposed development scheme, a reservoir and an intercepting drain shall be constructed at the west edge of the project area, and a regulating reservoir in the low lying land at the east coast, and the irrigation in the dry season shall be conducted by using the stored water in the said reservoir. Realization of this project will create 11,000 acres of agricultural land in the swamp area, and 7,400 acres of grazing land for beef-cattle breeding in the hilly lands of the southern part of the swamp area.

This project requires about 10 years and approximately US$9,400 (TT$18,800,000) for construction. Benefit-Cost Ratio of this project is about 1.12 and Internal Rate of Return is 7.8 percent. It is expected that rice yields will be about 13,000 tons, maize about 3,000 tons, and soybean about 1,700 tons per annum respectively upon realization of this project. The settlers of 640 households will migrate to the irrigable area. Furthermore, the beef-cattle in 7,400 heads (adult cattle) will be bred annually. This scheme is expected to yield additional benefit of some US$817,000 (TT$1,634,000) annually. Moreover, the increase in above-mentioned agricultural products will contribute to the foreign currency saving by curtailing the import. Judging from the foregoing study and analyses of the project, we consider that the project is feasible both technically and economically.

The Government of Trinidad and Tobago attaches importance to self-sufficiency of food in its agricultural policy. It is earnestly desired, therefore, that the Nariva Swamp Development Project will be realized at the earliest for the benefit of the country.

Finally, we sincerely wish that the present report will not only give a full answer to the request for the Nariva Swamp Development Project but also contribute to the promotion of friendly relations and economic interchange between Trinidad and Tobago and Japan.

With my best compliments, I always remain,

Truly yours,

Kensaku Takeda
Leader of the Survey Team
of the Nariva Swamp Development
Project in Trinidad and Tobago

INTRODUCTION

Introduction

The Background and Purpose of the Investigation

The Government of Trinidad and Tobago requested the Government of Japan, through the Economic Mission dispatched to Trinidad and Tobago by the Government of Japan in 1965, technical assistance in the agricultural development of the Nariva Swamp in the central part of eastern coastal area of Trinidad Island.

In compliance with this request, the Government of Japan entrusted the Overseas Technical Cooperation Agency (OTCA) with the execution of investigation. In September 1966, the OTCA formed a reconnaissance survey team composed of three specialists headed by Mr. Kensaku Takeda, Deputy Chief, Designing Division, Agricultural Land Bureau, Ministry of Agriculture and Forestry, Government of Japan. The team was dispatched to Trinidad and Tobago to carry out the preliminary survey, wherein economic and technical studies on agricultural development of the Nariva Swamp area were made. The team conducted surveys on the existing state of the area and data collection for one month, coming to the conclusion that to develop the area was extremely necessary and feasible for the longstanding agricultural policy of Trinidad and Tobago. At the same time, the team recommended the Government of Trinidad and Tobago to prepare the basic data and conduct feasibility study, construct the pilot farms, and render a training and extension service for the farmers on the agricultural techniques.

Based on this recommendation, the Government of Trinidad and Tobago exerted itself to prepare the basic data through levelling of the Nariva Swamp and topographical mapping, and requested the Government of Japan for technical assistance in feasibility study preceeding the future implementation of the project for its early materialization.

In December 1968, the Government of Japan decided to conduct the feasibility study for this project. The OTCA organized a team composed of 11 specialists headed again by Mr. Kensaku Takeda. In March 1969, the team was dispatched to Trinidad and Tobago to carry out the feasibility survey including the field investigation for nearly 50 days.

Following this investigation, the team carried out analyses and scrutinies of the collected data, which were compiled the feasibility report in March 1970. The report contains the results of the technical, financial and economic studies for the Nariva Swamp Agricultural Development Project, and proves the project to be technically sound and economically feasible. Further details are described in the appendices.

Formation of the team

The members of the feasibility survey team and their assignments are stated below:

Chief of the team

Kensaku Takeda
Deputy Chief, Designing Division, Agricultural Land Bureau, Ministry of Agriculture & Forestry
(Planning)

Members of the team

Yukou Matsuura
Deputy Chief (Forage Crops Specialist), Forage Crops Division, Animal Industry Bureau, Ministry of Agriculture & Forestry
(Cultivation)

Masaru Sakomoto
Deputy Chief, Resources Division, Tokai Regional Office, Ministry of Agriculture & Forestry
(Soil Chemistry)

Isamu Sakane
Staff, Designing Division, Agricultural Land Buareau, Ministry of Agriculture & Forestry
(Hydrology)

Makoto Nakamura
Chief, Hydrology Research Laboratory, Agricultural Engineering Research Station, Ministry of Agriculture & Forestry
(Coastal Engineering)

Setsuzo Kikkawa
Senior Economist, Sanyu Consultants International, Inc.
(Agricultural Economy)

Hisatada Tanabe
Senior Engineer, Sanyu Consultants International, Inc.
(Drainage)

Shigeru Ito
Senior Engineer, Sanyu Consultants International, Inc.
(Foundation Engineering)

Tetsuro Hori
Senior Engineer, Sanyu Consultants International, Inc.
(Irrigation & Consolidation)

Hiroki Maeda
Sanyu Consultants International, Inc.
(Hydraulic Structure)

Hiroshi Yamamura
Development Survey Division, Overseas Technical Cooperation Agency
(Coordination)

Home office works were carried out with the assistance of the following engineers of Sanyu Consultants International, Inc., Japan.

Takashi Kawai
Seiji Takeuchi
Hiroshi Moriyama
Yoshitomo Miyanishi

Itinerary of the Field Survey

The survey team was divided into two groups, the first and the second groups. The first group left Tokyo on March 10 and arrived in Port of

Spain on March 13 after the meeting at the Japanese Embassy in Venezuela. The second group left Tokyo on March 13, and arrived in Port of Spain on March 14. The team conducted the field investigation for the period from then to April 19 after an interview with the officials of the Government of Trinidad and Tobago and the organizations concerned. The team compiled and submitted an interim report to the Government of Trinidad and Tobago with explanations given at meetings held with authorities concerned, and returned to Tokyo on May 2nd. The detail schedule of the survey works in shown in Appendix.

Acknowledgement

On submitting this feasibility report, first of all, deepest gratitude is hereby expressed for the support and cooperation rendered by Ministers and their staff of the Government of Trinidad and Tobago. The team's appreciation is also extended to the professors and staff of the University of the West Indies who in many ways gave every possible assistance for various laboratory tests, proper guidance, coordination and arrangement, and also furnished valuable publications, useful data, and all the equipments necessary for the survey as well as transportation during the survey period. But for such great assistance and guidance, the team could never have attained the expected results in such a limited period. The investigation in Trinidad and Tobago has been conducted smoothly and satisfactorily, and it is sincerely hoped that implementation of this project will contribute to enhancing economic and friendly relationship between Trinidad and Tobago and Japan.

Lastly, the team would again like to express its appreciation to those who provided valuable support and assistance in the execution of the investigation, especially those whose names are listed hereunder.

MINISTRY OF WORKS

Hon. V. L. Campbell	Minister
Mr. Errol Pouchet	Acting Permanent Secretary
Mr. Colin Taylor	Director of Drainage
Mr. Clarance Narain	Hydrology Engineer
Mr. D. Commissong	Soil Engineer
Mr. J. Sealy	Chief Technical Officer
Mr. John Price	Navet Dam Superintendent
Mr. Tony Smith	Water Resources survey Agency
Mr. Elton Wyke	Water Resources survey Agency

MINISTRY OF PLANNING AND DEVELOPMENT

Hon. Francis Prevatt	Minister of State
Mr. Eugene Moore	Permanent Secretary
Mr. Don Workman	Economist
Mr. Victor Williams	Administrative Officer

MINISTRY OF AGRICULTURE

Hon. L. M. Robinson	Minister
Mr. Frank Barsotti	Permanent Secretary
Mr. E. J. Hamilton	Chief Technical Officer
Mr. Mike Pecoy	Acting Technical Officer
Mr. George Phillip	Administrative Officer
Mr. Stephen Redman	Technical Officer
Dr. M. P. Singh	Project Director
Mr. Peter Newhouse	Senior Economist

CENTRAL STATISTICAL OFFICE

Mrs. R. Rawlins	Statistician

UNIVERSITY OF THE WEST INDIES

Prof. P. Selvanayagam	Civil Engineer
Dr. Harry Phelps	Hyd. Engineer
Mr. Compton Deane	Hyd. Engineer
Mr. Leon Taylor	Soil Engineer
Prof. S. MaConaghy	Soil Science
Mr. A. E. Kerr	Soil Science
Dr. N. Ahmad	Soil Science
Dr. D. R. Edwards	Economist

INTER AMERICAN DEVELOPMENT BANK

Mr. Rolando Porras

Mr. Cesar Atala

TEXACO FOOD CROPS DEMONSTRATION FARM

Dr. T. Carr

Table of Equivalents and Abbreviations

Table of Equivalents

Currency

1 U.S. dollar	2 T.T. dollars
1 T.T. dollar	US$ 0.5

Length

1 inch (in.)	2.54 centimeters
1 foot (ft.)	30.48 centimeters
1 mile (=5,280 feet)	1.609 kilometers

Area

1 acre	0.4047 hectares
1 square mile (sq.mile)	2.5889 square kilometers

Volume

1 cubic foot	0.0283 cubic meters
1 acre-foot	1,230 cubic meters
1 cubic yard	0.76 cubic meters
1 gallon	0.0045 cubic meters

Flow

1 cubic feet per second	0.0283 cubic meters per second
1 gallon per second	0.0045 cubic meters per second

Weight

1 pound (16)	0.4536 kilograms

Abbreviations

inch	in
foot or feet	ft
square mile	sq.mile
cubic feet	ft
cubic yard	yd
pound	lb
degree fahrenheit	°F
percent	%
kilowatt	kW
United States dollar	US$
Trinidad and Tobago dollar	TT$
Trinidad Government Railway Datum	T.G.R.
Foreign Exchange	F.E.
Local Currency	L.C.
International Financing Agency	I.F.A.
Agricultural Development Bank	A.D.B.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Outline of the Project

The purpose of the project is agricultural development by utilization of lands and water resources of the Nariva area on the east coast of Trinidad and Tobago. The project area is bounded by the Plum Mitan-Cunapo Southern Road, the Rio Claro-Mayaro Road, and the coast of Cocos Bay on the Atlantic Ocean. At present in this area are the lands and the water resources utilized nowhere but in the limited area along the Plum Mitan Road with low efficiency on a small scale.

The basic conception of the development is (a) to prevent the project area from being inundated by the surface streams flowing from the watershed in the rainy season[1/], (b) to make the Swamp area arable by securing irrigation water in the dry season, and (c) to utilize adequate areas of the hilly lands around the Rio Claro-Mayaro Road for beef cattle breeding by reclamation.

For eliminating the surface streams, both a reservoir[2/] and an intercepting drain[2/] located along the border line of the irrigable area are used. 85 percent of the surface streams from the watershed are stored once at the Cocal Reservoir and introduced into the regulating reservoir to be constructed in the internal land along Cocos Bay, and finally drained to Cocos Bay on the Atlantic Ocean at the time of low

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1/ "There is no distinction nor definition for the classification of the rainy and dry season. In general, the dry season is regarded as the period from January to April, and the rainy season from May to December".
Refered to "Trinidad Water Resources Survey" - Interim Report No.2 by M.M. Dillon Limited. February 1968.

2/ Each is called the Cocal Reservoir and the Turure Cut.

tidal level after passing through L'Ebranche Barrage of the regulating reservoir[1/] and L'Ebranche River mouth situated at the northern edge of the project area. The remaining 15 percent are fed into the intercepting drain (Turure Cut) and introduced into the Nariva Regulating Reservoir, and finally drained to Cocos Bay through the Barrage and L'Ebranche River.

Drainage and irrigation plans of the area to be developed are interrelated. Except the intercepting drain (Turure Cut), Nariva Regulating Reservoir and Barrage, most of the facilities of the reservoir (Cocal Reservoir) and the canals in the area are dually to be utilized as irrigation water sources and irrigation canals during the dry season. In other words, part of the stream flows in the rainy season of the Jagroma, Navet, and Anho rivers occupying 85 percent of the total watershed area is cut off and stored in the reservoir for the use of irrigation water sources during the dry season, and introduced into the irrigable area through the main and secondary canals. Most of these conveyance systems are of earth canals provided with the check gates, turnouts, and auxiliary structures.

Regardless of the season, dry or rainy, potentially productive lands of approximately 9,000 acres (3,650 hectares) can be irrigated through these facilities.

The irrigation water supplied to the entire area from the reservoir (Cocal Reservoir) in the basic year for irrigation planning, 1961, is 25,700 acre/feet (31,611 thousand cubic meters) which is equivalent to 2.3 feet per acre.

The location of the project area and the irrigable area, and the lay-out of the main structures are presented on the Exhibit I-1, and the main features of the project is shown in Table A.

1/ It is called the Nariva Regulating Reservoir.

Stages of Development

The development of the project is carried out for ten years in succession, and the following two stages are considered practical.

Stage I

The construction works of the first stage are to be completed in five years, and the followings are to be implemented:

(1) To construct the dike and reservoir (Cocal Reservoir)[1/] for cutting off and storing the stream flows of the above-stated rivers during the rainy season.

(2) To construct part of the Plum Mitan Irrigation Canal along the high-lying land of the irrigable area from the Cocal Reservoir.

(3) To construct the waterway (Cocal Cut) from the Cocal Reservoir through the existing Nariva River to Cocos Bay.

(4) To construct part of the drainage systems.

(5) To irrigate 2,800 acres (1,150 hectares) through the dry and rainy seasons.

Stage II

Irrigation and Drainage Works

The construction works of the second stage are to be started immediately after completion of the first stage and completed in five years. During the stage the following works are to be implemented:

1/ The crest of the dike is to be used as the main road of the project area.

(1) To construct the Turure Cut which conveys to the Nariva Regulating Reservoir the surface streams flowing from the remaining watershed area not involved in the first stage.

(2) To construct the Nariva Regulating Reservoir along Cocos Bay, the Barrage, the estuary works of L'Ebranche river for draining to the Atlantic Ocean through the river mouth and to close the Nariva river mouth.

(3) To construct the irrigation canals[1/] along the medium elevations of the irrigable area from the Cocal Reservoir.

(4) To construct the remains of the Plum Mitan Irrigation Canals.

(5) To construct the remains of drainage systems in the irrigable area.

(6) To irrigate approximately 6,200 acres (2,500 hectares), the remaining area not included in the first stage.

Reclamation Works

The construction works of this stage are to be started after completion of the first stage and to be completed in five years. In this stage, the reclamation work covers approximately 15,500 acres (6,280 hectares) of southern hilly forest zone of the irrigable area, of which approximately 7,400 acres (3,000 hectares) of sporadic areas suitable for beef cattle raising will be utilized for grazing lands.

Purpose of Staging

A span of ten years is necessary as a reasonable period for the agricultural development of approximately 26,500 acres (10,730 hectares), of

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1/ It is called Bois Neuf Canal.

which an area of approximately 11,000 acres (3,650 hectares) is a gross irrigable area. Staging of the project would avoid indiscreet investment and reduce the undue concentration of construction effort. The order and the period of development stated above are based upon the results of the technical and economic studies.

Project Needs and Benefits

Economic stability of a country greatly depends upon the self sufficiency of food. Most of grains and meats, amounting to 24 percent of the import cost excluding petroleum, are imported from several countries of the British Commonwealth of Nations and the United States of America. Even though those countries produce the agricultural products at the cheapest cost in the world, the import of Trinidad and Tobago from those countries will result in exhausting precious foreign currency reserve. If Trinidad and Tobago herself produces food in her idle areas at the competitive cost with those countries, it will greatly contribute to the economy of the country.

The Nariva Swamp is the largest area suitable for agricultural development left in this country. To convert the area into paddy fields is not technically so difficult. The cost for that will be cheaper if soft loan is granted on the foreign exchange portion. The products after completion of the works will account for 41.5 percent of rice imports, 10.2 percent of corn imports, and 17.6 percent of bean imports in quantity respectively, so that savings of the foreign exchanges are expected to amount of approximately TT$4,400,000 (US$2,200,000) per year. This amount is almost equal to ten times that of annual amortization for soft loan. Further, annual expenditures in local currency is TT$566,000 for the first stage, and TT$960,000 for the second stage. These amounts are unavoidable preinvestment for the savings of the foreign exchange stated above, but the benefit is expected much larger than the amounts of the pre-investment.

Since the project requires both the irrigation and drainage facilities in view of the topographic condition, the construction cost per unit area is comparatively high. Also, the cost of agricultural products should be evaluated, based upon unit price of cheap agricultural products currently imported. Therefore the benefit-cost ratio is apparently low, but it should be noted that the project will bring about numerous merits and benefit. In order to avoid the influence of the world trading conditions and changes of the international politics, an increase of the degree of food self-sufficiency is necessary for Trinidad and Tobago as an independent country. For that, settlement of farmers should be so planned that they can fully make use of the highly productive, agricultural techniques.

The benefit as the basis of the annual benefit computation is determined by the net income of the farmers, which can be obtained by deducting the necessary expenses for production from the estimated value of agricultural products in the irrigable area available some years after completion of the construction works. Because, for a gaining of the full benefit (target yield) a training period is necessary. Annual benefit is the average annual equivalent in the period of economic analysis period including training period. Provided that the training period is five years, the economic analysis period is fifty years, and the rate of interest is seven percent, the annual benefit in irrigation section is TT$179.00 per acre, and the annual benefit accruing from all the irrigable area is TT$1,611,000. Further, the annual benefit in the livestock section is TT$51.00 per acre, and the annual benefit accruing form all the livestock area is TT$377,400.

Construction Costs

By estimating the construction cost of every structure, the total construction cost of each stage is obtained. An estimation of the construction cost and its both components, i.e., foreign exchange and local currency, is conducted on the basis of price level prevalent in Trinidad

and Tobago during the period of 1966 to 1969 and the world price level of 1969.

However, the land improvement cost is estimated by referring to the standards in Japan due to lack of the data of Trinidad and Tobago.

Total Construction Costs

Unit: US$1,000

	Foreign Exchange	Local Currency*	Total
Stage I	1,135	1,737	2,872
Srage II			
Irrigation	2,185	3,100	5,285
Livestock	-	1,200	1,200
Total	3,320	6,037	9,357

* Inclusive of the land improvement cost.

The construction costs are approximately US$570 per acre, and costs of irrigation and livestock aspects are US$900 and US$160 per acre, respectively.

Annual cost necessary for the economic analysis is the average annual equivalent during the economic analysis period. Of the total initial investment cost during the construction period and the replacement cost, and the operation and maintenance cost during the analysis period. Provided that the economic analysis period is 50 years, construction period is 10 years, and the rate of interest is 7 percent, the annual cost in the irrigation section is US$67.6 per acre, and that of the livestock section is US$16 per acre.

Benefit-Cost Ratio

Benefit-Cost ratios shown below are calculated by using the annual cost and the annual benefit which have been obtained in the preceding section.

		Benefit-Cost Ratios
Stage I	Irrigation	0.96
Stage II	Irrigation	1.14
	Livestock	1.53
Full Development		1.12

Note: Stage I plus Stage II Irrigation 1.06

Internal Rates of Return

Internal rates of return are computed by using the annual benefit and the annual cost, based on the farmers' net income. The internal rates or return for each section (irrigation and livestock) and those for the full development are as follows:

	Internal Rates of Return
Irrigation	7.4%
Livestock	10.1%
Full Development	7.8%

Necessity of Project Organization

It is proposed that the project will be implemented by an independent organization authorized by the legislature of the Government of Trinidad and Tobago, because it necessitates consolidated system for

allotment of lands, construction and operation of the project, technical and financial assistance to farmers, and loans procedures from the international financing agencies authorized by the legislature.

Farm Settlement

Farmers of 640 households are to settle in the irrigation and drainage area, where 14 acres of arable land and 1/2 acre of residential lots are allotted to each household. Annual income per household in the area is to be equivalent to that in urban areas, or TT$4,594, which would allow farmers to enjoy the same living standard as the city wage earners. Of this income, TT$366 can be appropriated for annual repayment to cover the amortization of TT$276 for the land improvement and about a half of the operation and maintenance cost (TT$82/household, TT$5.8/acre) for the irrigation and drainage facilities. If in future maintenance and operation of the project are continued by the Governmental management, it will be possible to double the current rent of TT$6.0/acre of the Crown land. Trinidad and Tobago must determine as to whether the operation and maintenance cost should be covered by collection of the water charge or by raising the rent of the Crown land.

Financial Forecast

46.5% of the project constructon cost and the total procurement cost for the agricultural machines are expected to be appropriated by foreign exchange loan from the international financing agency.

The local currency portion of the project construction cost is to be covered by the budget of the Government of Trinidad and Tobago, and the required funds for the land improvement and the cooperative facilities shall be managed by a loan from the Agricultural Development Bank. The costs of the other public facilities are to be covered by the general

financial expenditures of the Government.

As the result of the financial study, the repayment plan and the expenditures of the Government stated above, prove economically feasible.

Agricultural Services

It is necessary that settlers shall be technically assisted in such aspects as the land preparation, construction of farm ditches, proper utilization of the irrigation water, cultivation of the crops and raising of the livestocks. The authority shall assist the settlers in the affairs relating to the settlement, and the central agricultural experiment station and the agricultural extension service at site shall give them every possible instruction on agricultural techniques. Training, operation and maintenance on mechanization shall be conducted by joint operation on farm management at the responsibility of both the authority and the cooperative.

Conclusions and Recommendations

Conclusions

Self-sufficiency of food would have a serious influence on economic stability of a country. Precious foreign currency of this country is being spent every year for food import from countries which produce agricultural products such as cereal crops and meat at the lowest cost. If the country can produce such foods at competitive costs by the development of unexploited lands, it can contribute immensely to economic stabilization of the country.

The Nariva Swamp area is the largest swamp which has been left un-

cultivated in spite of its suitability to agricultural lands, and it is not so difficult technically to convert the swamp into paddy fields. The development cost is not much expensive and the repayment for loans will not be so difficult, if foreign currency component is financed by soft loan terms.

Conclusions of the present feasibility study are summerized as follows.

1. From technical and economic viewpoints, a net irrigable area of 9,000 acres (3,650 hectares) and a beef-cattle breeding area of 7,400 acres (3,000 hectares) are selected as suitable for development, after thorough survey in an area of 62,000 acres (25,000 hectares) consisting a part of the watershed area, the irrigable area and livestock area.

2. Drainage of excess water and development of drainage system in the swamp area are particularly important for promotion of land utilization. Since a pumping drainage system is not profitable in this case, a gravity drainage plan is adopted for the project.

3. For the development of cropping pattern in this region, a supplemental irrigation in the wet season and a thorough irrigation in the dry season are required. The gravity irrigation is available by construction of the dike and reservoir (Cocal Reservoir) at the hillside of the Bois Neuf in consideration of topographical conditions.

4. Paddy, maize and soybean are main crops in the irrigable area. In the wet season, paddy shall be cultivated in the whole area, and in the dry season, paddy shall be cultivated in half of the whole area, and maize and soybean evenly in the rest of the area.

5. Total yields cover 41.5 percent in paddy, 10.2 percent in maize and 22.9 percent in soybean, and 17.6 percent in beef in the total imports in the respective agricultural products.

6. 640 households of settlers shall receive an allotment of 14 acres for irrigation and 0.5 acres for residential lot.

7. Total construction cost in the sector of irrigation and drainage amounts to US$8,157,000 (US$906 per acre). US$3,320,000, 46.5 percent of the total amount, is to be loaned in foreign currency by the international financing agency, and the remainder is to be disbursed from the general budget of the government.

8. The cattle breeding scheme shall be carried out in either system of the national estate or the private estates and its construction cost amounts to US$1,200,000 (US$162 per acre), which shall be prepared in local currency.

9. On 7 percent of the interest rate, the benefit-cost ratio is 1.06 in the irrigation aspect and 1.53 in the cattle breeding aspect. The internal rate of return is 7.4 percent in the irrigation aspect and 10.1 percent in the cattle breeding.

10. The settlers in the irrigable area can have repayment capacity enough for amortization of the land improvement cost and for paying as water charge a half of the operation and maintenance cost of the irrigation facilities. In the case that the government will continue to execute the operation and maintenance of the irrigation facilities under its control even in the future, it will be able to raise the rent of the Crown land by TT$6.0 per acre into double, instead of collecting the water charge mentioned above.

11. The amortization and foreign currency shall be carried out by the government. The amount of amortization is equivalent to about 1/10 of saved foreign currency from import substitution by the production in the project area.

12. Development Authorities shall be newly established under the control

of the Nariva Swamp Development Committee in order to achieve the purpose of the project.

Recommendtations

The following recommendations are given for the accurate execution of construction and realization of anticipated benefit of the project.

1. To make earlier preparation for government budget and personnel required for execution of field tests for mechanized cultivation of paddy, maize and soybean since the land of 100 acres is reserved for agricultural research station in the irrigable area; and to commence basic tests necessary for mechanized cultivation of paddy at the central agricultural experiment station for smooth implementation of the above program.

2. To build urgently a pilot demonstration farm of 500 acres, which shall be annexed if possible, to the central agricultural experiment station, with emphasis on the establishment of the mechanized cultivation method of paddy, maize and soybean; and to conduct training to the would-be qualified settlers with mechanization farming practice in advance of the commencement of settlement.

3. To invite applicants for settlers and to select the qualified settlers at the earlier stage in order to provide the foregoing training; namely, to select the fully qualified settlers by paying attention their competentance, technical knowledge and mentality for performing cooperative farming by mechanization, and furthermore, reserves for living cost and other materials needed at the beginning period of the settlement.

4. To make an endeavour to establish a public organization which would give advice and guidance for the construction works, operation and maintenance of the facilities, and farm management after completion of the project.

5. To continue the hydrological observations, to make detailed topographical maps, and to clarify conditions such as topography, soils, vegetations necessary for decision of the livestock breeding lands.

Table A

Main Features of the Project

Proposed area	
Watershed Area	366.43 sq.km (141.54 sq.mile)
Project Area	10,730 ha (26,500 acres)
Gross Irrigable Area	4,450 ha (11,000 acres)
Net Irrigable Area	3,650 ha (9,000 acres)
Proposed Livestock Area	6,280 ha (15,500 acres)
Livestock Breeding Area	3,000 ha (7,400 acres)
Irrigation & Drainage facilities	
Cocal Reservoir	Dike length 11.6 km (7.2 miles)
	Gross storage capacity 43,173 x $10^3 m^3$ (35,100 acre-feet)
	Reservoir surface area 1,700 ha (4,200 acres)
	Full water surface level 36.1 m (118.3 feet)(T.G.R.)
Nariva Regulating Reservoir	Gross storage capacity 205,410 x $10^3 m^3$ (167,000 acre-feet)
	Reservoir surface area 2,600 ha (6,400 acres)
	Full water surface level 30.4 m (99.6 feet) (T.G.R.)
Turure Cut	Peak discharge 63.1 m^3/sec 9.0 km (5.6 miles)
Plum Mitan Irrigation Canal	Peak discharge 15 m^3/sec 4.8 km (3.0 miles)
Bois Neuf Irrigation Canal	Peak discharge 3.6 m^3/sec 9.5 km (5.9 miles)

L'Ebranche Estuary Barrage (3.9 m in height, 7.5 m in width - 3 sets)

Mean high-water-level of spring tide 99.5 feet (T.G.R.)

Mean low-water level of neap tide 96.7 feet (T.G.R.)

Scale of farm management

Settled households	640
Farm size per household	5.67 ha (14 acres)
Cropping pattern	Paddy 100% for rainy season Paddy 50% for dry season Maize 25% for dry season Soybean 25% for dry season
Livestock farming	Estate system
Beef cattle to be bred	7,400 heads (adult cattle)

Economic evaluation

Construction cost	US$8,320,000
Annual benefit (Total)	770,000 (about)
Annual cost (Total	690,000 (about)
Benefit-cost ratio (7% of interest rate)	1.12
Internal rate of return	7.8%

Table B Funding Requirement

1,000 TT$

	Stage I						Stage II						Grand Total
	1	2	3	4	5	Total	1	2	3	4	5	Total	
Irrigation													
F.E.	454	454	454	454	454	2,270	874	874	874	874	874	4,370	6,640
L.C.	566	566	566	566	1,210*	3,474	960	960	960	960	2,360*	6,200	9,674
Reclamation													
F.E.							-	-	-	-	-	-	-
L.C.							480	480	480	480	480	2,400	2,400
Total													
F.E.	454	454	454	454	454	2,270	874	874	874	874	874	4,370	6,640
L.C.	566	566	566	566	1,210	3,474	1,440	1,440	1,440	2,840	2,840	8,600	12,074

* The land improvement cost shall be invested in the last year of the scheduled period for each stage.

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CHAPTER I

THE NARIVA SWAMP AGRICULTURAL DEVELOPMENT PROJECT

The Project Area

The Nariva Swamp is located at the eastern part of Central Trinidad as shown on Exhibit I-1, and the ground is sloped down toward Cocos Bay on the Atlantic Ocean from the Central Range. The area related to the agricultural development project of the Nariva Swamp is about 62,000 acres (about 25,000 hectares) wide, and is bounded by hilly land or high land, while the east side of the area faces the Atlantic Ocean.

The project area is bounded by the Lower Manzanilla Road - Plum Mitan Road and Cunapo Southern Road at the northwest side, the Rio Claro - Mayaro Road on the south side, and faces the Atlantic Ocean at the east side. The eastern edge of the swamp area is separated from the Atlantic Ocean by a narrow beach bank, which has been developed for coconut plantation.

Based on the field investigation and study, southern sloped hilly lands as well as flat plains excluding a leases of Crown land and private lands are selected for the new development project (Refer to Exhibit I-1).

Division	Area	Remarks
Flat plains	11,000 acres (4,450 ha)	gross irrigable area
Sloped Hilly Land	15,500 acres (6,280 ha)	proposed livestock area
Total	26,500 acres (10,730 ha)	

A number of rivers run into the irrigable area from its adjoining watershed, so that in the rainy season these rivers cause flood and inundation of the Swamp area. In order to store once and drain off the sur-

face streams of these rivers, the reservoir (Cocal Reservoir) and the intercepting drain (Turure Cut) are to be constructed, and the former is to be utilized for the water sources as well during the dry season. The main rivers and its relative areas in the watershed adjacent to the irrigable area are shown as follows:

Watershed Division	Area of Division (square miles)	Area of Division (percents)	Main Rivers
(A)	1.85	1.3	-
(B)	4.17	2.9	Petite Poole Cut
(C)	13.90	9.8	Cuche Canque River
(D)	5.33	3.8	Jagroma Cut
(E)	13.05	9.2	Charuma River
(F)	65.60	46.4	Navet River
(G)	37.64	26.6	Anho River
Total	141.54	100.0	

At present, a part of the Plum Mitan area finds only 500 acres (200 hectares)[1/] farmed for paddy production during the rainy season, while the other areas hardly present cultivation. Most of the rivers and creeks from the watershed get lost their traces as rivers at the flat plains with the elevation of 110 feet (T.G.R.)[2/] around the northwest part of the swamp and flood over the wide area. Therefore all facilities which function to cut off and to drain the water by gravity are to be located along this elevation. In the same way, the gravity irrigation is to be available for the lower flat plain than 110 feet (T.G.R.).

Ten years ago, as a Plum Mitan River Scheme, a development project has been conducted on approximately 1,200 acres (490 hectares) of the north

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1/ The terminal parts of the drainage canals are buried by sediments and lowered function of the system makes the cropping area diminished year by year.

2/ Trinidad Government Railway Datum Mean Sea Level = 96.62 feet (T.G.R.)

part of the Nariva Swamp area. In brief, the project had functions to cut the flood waters from the watershed by the Jagroma Cut, Cuche Cut, and Petite Poole Cut, and to irrigate the area with effective surface streams. But at present the lack of the effective surface streams during the dry season, the adverse flows of the flooding waters from the Navet and Anho rivers during the rainy season, and the lowered functions of the drainage canals because of its terminal being buried by sediments enable the farmers to cultivate the paddy only on about 500 acres (about 200 hectares).

Irrigable lands are very flat, composing of heavy clay soil, and at present drainage function by gravity is poor, but the land is highly productive.

Rainfall depends greatly upon the location of the project area as well as upon the change of seasons. Most of the rainfall concentrated cause the flood during the rainy season or from May to December, while for the dry season from January to April it is less, accounting for as much as 15% of the annual rainfall. The observation records of rainfall of the irrigable area and the surrounding areas are shown on Exhibit I-3.

At present, the flood is drained to the Atlantic Ocean only through the Nariva River along the east coast. The coast line along Cocos Bay facing the Atlantic Ocean belongs to violent wave breaker zone, of which the movement of the sand is extremely great. Therefore, for the protection of the existing river mouth, constant flow to flush the drifting sand would be necessary. Presently, the flood water stored in the swamp during the rainy season and tidal discharge during the dry season take a role of the constant flows. Therefore, it is necessary to check the availability of maintenance of the river mouth against the variation of the flows made by the project plan from the watershed.

The annual mean temperature of the Navet damsite in 1968 is maximum 84° Fahrenheit, and minimum 72° Fahrenheit, and there is not so large fluctuation in every month (Exhibit I-3). At the Cocal and the Tunure

Wards located in the irrigable area, approximately 2,200 farmers' houses are found. Their farming areas are ranged from 1 acre (0.4 hectare) to 100 acres (40 hectares). About 58 percent of the farmers are managing at farm size less than 10 acres (4 hectares), and the total farming area accounts for 16 percent of the whole cultivated land. On the other hand, the farmers managing at farm size more than 50 acres (20 hectares) accounts for only 4 percent and the total area accounts for no less than 50 percent. The most ordinary farm size is ranged from 10 to 24 acres (from 4 to 9.7 hectares), and the farmers who manage the farms of these sizes account for 31 percent of the whole farmers.1/

In those farms, various crops such as tree-crops, field crops, vegetables, and fruits are cultivated through a year.

On the hilly land adjacent to the irrigable area there inhabit approximately 150 farmers who engage in cultivation of the Plum Mitan area, and also very few farmers who cultivate the area temporarily without permission during the dry season. Further, a very few inhabitants engage in the seasonal hunting and the seasonal fishery in the Swamp (mainly catching cascadure fish). Therefore, as agriculture develops in future, farmers of the other areas will be necessary to be settled in this area.

The irrigable area is located convenient enough for marketing. The area is approximately 45 miles from Port of Spain the capital of Trinidad and Tobago and the travel time through the paved road is approximately 2 hours in normal speeds.

Project Plan

The project plan is basically to control water, and irrigation and drainage are closely related. The drainage scheme covers the project area

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1/ "Land Use by County and Holding Size." Agricultural Census, Section 2, 1963.

and the watershed area adjacent to the project area, totalling approximately 158.72 square miles, the irrigatin scheme covers the area of approximately 11,000 acres (4,450 hectares) lower than the elevation of 110 feet (T.G.R.) and the livestock breeding is applied to the hilly lands along the Rio Claro - Mayaro Road, totalling approximately 15,500 acres (6,280 hectares).

Drainage Scheme

As stated above, the basic conception of the project plan is on the drainage. It is classified into the following: to control of the surface streams from the irrigable area and from the watershed adjacent to the irrigable area, and to drain off those water through the Nariva Regulating Reservoir to the Atlantic Ocean.

The Watershed Division (A) is of hilly land which forms a rather belt-like shape and the area is small, accounting for 1.3 percent of the entire watershed area. Therefore, the surface streams are caught directly into the Nariva Regulating Reservoir, and drained to Cocos Bay by gravity through L'Ebranche barrage and L'Ebranche Cut.

The Division (B) and (C) account for approximately 13 percent of the whole watershed (Exhibit I-2), and the food of the Central Range in the divisions has been relatively developed for the estate. The river routes are almost keeping their shapes. Flood waters of these divisions are caught, through all rivers and tributaries, by the intercepting drain (Turure Cut) located along the estate around the elevation of 110 ft. (T.G.R.), and led to the Nariva Regulating Reservoir for the drainage.

Most of the Division (D) to (G) are of unclutivated forest zone, accounting for approximately 86 percent of the whole watershed area (Exhibition I-2). The shapes of river routes are not even, and the flowing capacity of the rivers is not enough. Above all, at the plain of the Swamp side, only the traces as the river are scarecely found, so that the rivers flood over the wide area. The flood water is caught and stored

once in the Cocal Reservoir, and the water is introduced by the waterway (Cocal Cut) at Bush Bush site, to the Nariva Regulating Reservoir set up at the low-lying area behind the east beach bank.

The flood water in the irrigable area is allowed to inundate the paddy fields for three days with the water level of less than 1 feet, caught into the main drainage canals through the drainage system after storing in the field for a while, and introduced to the Nariva Regulating Reservoir located at the last reach of the canals.

As stated above, the surface streams except the division (A) are caught and stored once in the Nariva Regulating Reservoir provided at part of elevation less than 99 feet (T.G.R.) at the eastern tip of the irrigable area. By a favourable topographic condition of the coastal line and constant base flow for flushing the drifting sand, L'Ebranche river mouth are well maintained. Therefore the stored water is to be drained at the low tidal level by gravity through the barrage to L'Ebranche River flowing down from the outside watershed adjacent to the northern tip of the project area. Needless to say, the river mouth of L'Ebranche River is to be improved in width.

Irrigation Scheme

Irrigation is conducted in a manner that some of the flood water of the rainy season in the Division (D) to (G) are stored in the Cocal Reservoir, from which, the irrigation water is supplied for the water shortage during the dry season. Therefore, almost of the facilities for drainage, except the Turure Cut, the Nariva Regulating Reservoir, and the Barrage, are utilized for irrigation, too. The Cocal Reservoir can store approximate 35,100 acre/feet by the low-elevation-dike ranging from the top of the Jagroma Cut through Bois Neuf to Bush Bush, and irrigate the whole cropping area during the dry season.

All irrigation water is introduced by gravity through the two canals: the Plum Mitan Irrigation Canal located at the highest land of the

irrigable area of elevation 110 feet (T.G.R.) continuous to the Turure Cut used for flood water drainage in the watershed areas (A) to (C); and the Bois Neuf Irrigation Canal provided along elevation 105 feet (T.G.R.) starting from Bois Neuf. In these canals, check gates and turnouts are installed and the irrigation water is distributed to all paddy fields by this canal system.

Livestock Scheme

In view of the effective utilization of land and import status of meat in Trinidad and Tobago, the suitable area for beef cattle breeding is sporadically selected in the forest zone of sloped hilly land of the Division (G), which accounts for about 50 percent, i.e. 7,400 acres (3,000 hectares) of the proposed area of 15,500 acres (6,280 hectares). The area is to be reclaimed for a grazing land without irrigation. Over the reclaimed land, roads and drinking water facilities for cattle are to be provided.

Stages of Development

All the development works in the project area approximately 26,500 acres (10,730 hectares) are not to be started at once, but implemented for 10 years in succession. For this, all the work schedules are classified into two optimum stages in consideration of financial, economic and administrative aspects.

Irrigation and Drainage Scheme

Stage I

3,550 acres (1,420 hectares) at the high-lying land of the swamp including the Plum Mitan area to be improved are selected as the irrigable area for the initial stage.

The works required in this stage are as follows;

(1) Construction of the Cocal Reservoir to store the flood water of the Jagroma, Navet, and Anho River of the Division (D) to (G).

(2) Construction of part of the Plum Mitan Irrigation canal conducting the water from the Cocal Reservoir through the high-lying land of the irrigable area to the Petite Poole Cut.

(3) Construction of the drainage canal (Cocal Cut) from the Bush Bush site of the Cocal Reservoir to the Existing Nariva River mouth.

(4) Construction of the drainage system including improvement of the Petite Poole Cut and the Jagroma Cut.

(5) Construction of the diversion and distribution systems, and levelling of paddy fields, in the irrigable area.

This stage is to be completed in five years.

Stage II

The low-lying land of the swamp of 7,450 acres (3,030 hectares), which is the remaining portion of Stage I, is to be for the second stage. Main works are to provide all facilities for draining the flood waters in the irrigable area and the watershed area adjacent to the irrigable area to the Atlantic Ocean. Five years are planned for completion of the second stage.

All the works included in the second stage are as follows;

(1) Construction of the intercepting drain (Turure Cut) for catching the flood water of the Division (A) to (C).

(2) Construction of leading canal in the Nariva Regulating Reservoir and dike for the Reservoir, and closure of the Nariva River Mouth.

(3) Construction of the barrage and the wasteway leading to the Atlantic Ocean, including the improvement works of L'Ebranche River Mouth.

(4) Construction of the remaining drainage system in the irrigable area.

(5) Construction of the remainings of the Plum Mitan Irrigation Canal, from the Petite Poole Cut to the terminal.

(6) Construction of the main canal (Bois Neuf Irrigation Canal) along the elevation 105 feet (T.G.R.) conducting the water of the Cocal Reservoir from the Bois Neuf site.

(7) Construction of diversion, conveyance and distribution systems and the land levelling in the second irrigable area.

All the construction works of irrigation and drainage in the second stage are to be completed after 10 years, if started soon after completion of the initial stage.

Livestock Scheme

This scheme is to be started after completion of the stage I of irrigation and drainage. Among approximately 15,500 acres (6,280 hectares) of the forest zone of sloped hilly land south of the irrigable area, the optimum land of approximately 7,400 acres (3,000 hectares) is to be reclaimed for beef cattle breeding. For the completion of the works, five years are necessary.

This scheme includes construction of road system and water-supply facilities for livestock, and land reclamation by cutting and uprooting of trees.

History of Development Plan

The irrigable area has great potentiality for agricultural development. The study was conducted on the area ten years ago and the Plum Mitan Rice Scheme was implemented for development of 1,200 acres (490 hectares) around the Plum Mitan area north of the irrigable area. Investigations which were systematically conducted are stated in the Expanded Technical Assistance Program of 1957 by F.A.O.[1/], and the Reconnaissance Report of 1967 by O.T.C.A.[2/] in Japan.

Every report holds enough valuable and useful contents for the development plan, but it is not always perfect because of the unsatisfied investigation and data.

F.A.O. report does not clarify the concrete development plan, but it presents the following orientation for the development;

(1) Development of the Nariva Swamp has to be stated from the west high-lying land in sequence.

(2) Unless overall development is started, a development of polder system in the plain of 4,600 acres (1,860 hectares) existing at the relatively high elevations is desirable to be planned.

1/ Report to the Government of Trinidad and Tobago on the Reclamation of the Caroni Oropouche and Nariva Areas. Food and Agriculture Organization of the U.N. 1957.

2/ Agricultural Development Project for the Nariva Swamp in Trinidad and Tobago. Overseas Technical Cooperation Agency, Government of Japan (O.T.C.A.), 1967.

(3) It is most important for development that the drainage condition shall be improved in integral combination of the improvement works of a number of rivers flowing into this area.

The report suggests that since the soil condition of the swamp in Trinidad is generally not fertile and the project cost becomes higher due to the drainage construction works, the reclamation of the swamp for arable land is not very worthy development to be actively initiated.

According to the report of O.T.C.A. (1967), some items are suggested to be checked by future investigations and studies, but the basic conception for the project plan is outlined as follows;

(1) to plan the double-polder dike type providing a water table (a regulating reservoir) between the arable land and the outer ocean.

(2) Surface streams are to be drained through the main drainage canal and regulating reservoir to the ocean after being caught by the intercepting drain. The flows from the Central Range are to be conducted to the main drainage canal by the Navet river and drained to the ocean on the shortest course.

(3) The surface streams from the Nariva area is to be drained to the Atlantic Ocean by the regulating barrage provided near the existing Nariva river mouth in relation to the regulating reservoir and the tidal level.

(4) Irrigation water is taken from the regulating reservoir and the main canals functioning as the water source and supplied by the gate for raising water level and pumps.

(5) In case the development plan is partly implemented, initially the improvement of the Plum Mitan area is conducted. Secondly, it is hopeful to be started with the development for the high-

lying land of the west side. But the main drainage canal and the regulating barrage leading to the sea are to be constructed in consideration of the future project scale.

According to this report, it is concluded that development of the Nariva Swamp area to the arable land has great necessity and feasibility in view of the long term agricultural policy and economic development in Trinidad and Tobago.

The investigation conducted this time clarifies the following main points: Utilization of L'Ebranche River as the position for drainage of the flood water to the Atlantic Ocean; and construction of Cocal Reservoir for irrigation water supply as well as storing the flood water from the basin.

Scope of Field Investigation

The plan has been based on the field investigation made by the dispatched team and the useful data obtained. Besides of continuous observation of hydrology such as precipptation, river discharge, and tidal level, additional drilling for foundation and geographical survey are necessary for the detailed designing of various structures.

The investigation which has been conducted this time includes the followings;

Topography

A chart of contour intervals 25 feet with 1:10,000 and 1:25,000 of scale, published by B.G.M.O.D.[1/] has been provided as a topographical one for the irrigable area. Further reference has been made to levelling

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1/ British Government Ministry of Overseas Development, 1966

data which had been conducted by the Geographical Bureau of the Trinidad Government. These charts do not include the hilly land south of the irrigable area, and the contour intervals have been not adequate for such a flat plain. Therefore additional field survey has to be conducted in future. The supplemental survey which has been conducted this time contains the geographical survey of the L'Ebranche River mouth and the Nariva River mouth, and the levelling survey along the Plum Mitan Cunapo Southern Road.

Hydrology

Precipitation record at the 8 sites of the watershed area and the irrigable area and discharge record of the Navet River and the Pure River in its adjoining watershed have been obtained. Total 14 samples have been collected from the relative rivers on which runoff analysis has been made, and the water quality test have been conducted on these samples.

Agricultural Soils

Selecting an area of the representative soil texture among the irrigable area, section survey has been conducted at several sites. Soil sampling has been carried out at the seven sites among them and the analysis of the samples have been arranged to be made by the University of the West Indies. These surveys have been conducted in order to obtain the basic data for the classification of the soil and the land utilization.

Foundation Exploration

At the sites the construction of the main structures is proposed, diamond drilling and test pit excavating have been conducted. Total 5 holes have been drilled and its total length is 175 feet, while the test pits are 3, and the soil test for each core sampled has been asked to the University of the West Indies.

Coastal Survey

In order to grasp the correlation between the existing river flows and the tidal level at the Nariva River mouth, the observation of the tidal level and the discharge of the Nariva River have been conducted. Sampling of the beach sand in 9 materials has been carried out, and soil grading and density test have been arranged to be made by the University of the West Indies.

Economic Investigation

An investigation by agricultural economists has been made to the present status of agriculture, production cost of various crops, and collection of statistical data in Trinidad. Also the investigation has been made to wholesale market of agriculture products, construction materials and labor market situation.

In this country whose population and area are small, it is extremely important to clarify the international environment in relation to agricultural imports and exports, so that the investigation on the Rice Agreement of the Caribbean Free Trade Association (C.A.R.I.F.T.A.) treatment[1/], as well as part which completes with agriculture of the related countries were conducted. Further a study on the Checchi Report[2/] by Inter-American Development Bank has been carried out.

1/ Ministry of Planning and Development C.A.R.I.F.T.A., Port of Spain: Economic Mission for Latin America, 1968.

2/ Bank of Trinidad and Tobago, Report and Recommendations on the Agricultural Development.

Chapter II

DRAINAGE SCHEME

Drainage Features

The Nariva Swamp development Project essentially aims to drain floods and excess waters in the wet season, and the Cocal Reservoir and the drainage canals in the project area are to be used as the irrigation facilities as well. Explanations to the drainage systems and their main facilities are given as follows.

Drainage Systems

Drainage are classified into three systems; drainage from the watershed adjacent to the irrigable area to the Nariva Regulating Reservoir, drainage from the irrigable area to the Nariva Regulating Reservoir and drainage from the Nariva Regulating Reservoir to Cocos Bay, the Atlantic Ocean. The approximate total area related to the Nariva Swamp Development Project is 158.72 square miles, and an area of the watershed adjacent to the irrigable area is 141.54 square miles and is ramified into small divisions by numerous rivers and creeks.

Division of Watershed	Area of Watershed (%)	Existing Main Rivers	Designed Drainage System
A	1.85 sq.miles (1.3)	-	Nariva Regulating Reservoir
B	4.17 " (2.9)	Petite Poole Cut	Turure Cut
C	13.90 " (9.8)	Couche, Conque River	Turure Cut
D	5.33 " (3.8)	Jagroma Cut	Cocal Reservoir
E	13.05 " (9.2)	Charuma River	Cocal Reservoir
F	65.60 " (46.4)	Navet River	Cocal Reservoir
G	37.64 " (26.6)	Anho River	Cocal Reservoir
Total	141.54 sq.miles (100)		

The Division (A) of the watershed (Exhibit I-2) has a small area of 1.3 percent of the total watershed, existing in the hilly land in belt-like

shape, and the surface water is flowing down the large part of the area without showing any clear river route. Floods to this area is to be caught directly to L'Ebranche Cut leading the water from a barrage at the north end of the Nariva Regulating Reservoir to L'Ebranch River Mouth, and drained to Cocos Bay by gravity.

The Divisions (B) and (C) (Exhibit I-2) occupy about 13 percent area of the total watershed and the Division of the mountain foot is developed fairly well for the villages and estates. The traces as rivers form considerablly clear shapes. Floods to these divisions shall be caught by an intercepting drain (Turure Cut) running along the border line of the estate about 110 feet at the elevation (T.G.R.), and be drained to Cocos Bay through the Nariva river mouth after being conducted to the Nariva Regulating Reservoir.

The Divisions (D) to (G) of the watershed occupy 86 percent of the total watershed area and most of the area are covered with unexploited woods. The routes of rivers and creeks in the Divisions show unclear and irregular shapes and their flowing capacities are insufficient to drain floods. Especially around the area at elevation 110 feet (T.G.R.) of the border line between the hilly and the swamp area, the rivers show only their relics, and there come floods covering the vast area. The floods from these watersheds shall be stored in the Cocal Reservoir surrounded by the low dike, the crest of which shall be used as a main road in the area, and the floods shall be conducted to the Nariva Regulating Reservoir through the Cocal Cut at Bush Bush. Then, the flood water shall be drained to Cocos Bay through L'Ebranche River mouth after being regulated by the barrage.

The surface streams in the irrigable area shall be conducted to the Nariva Regulating Reservoir through drainage systems after a certain period of storage being allowed in the fields by the drain regulating notches, and then shall be wasted to Cocos Bay through L'Ebranche River after being controlled by the barrage.

Runoff of Each Drainage Basin

Runoff analysis is made on the data of the rainfall, and a spell of three raining days for a 10 year probability is taken as an object of study. There exists eight gauging stations in the area related to the Nariva Swamp development Project, and the longest-term observation has been made at the gauging station of the Newland Estate in the irrigable area.

The design point rainfall at each gauging station is derived from probable rainfall at the Newland Estate, based upon the proportional distribution between the rainfall of the Newland Estate and the rainfall at each gauging station, as a result of the statistical study on the correlation between the rainfall of the Newland Estate Gauging Station and that of the other gauging stations. Design areal rainfall of the whole area relating to the irrigable area is computed by employing the Thiessen Method and shown in Table II-1.

As for a rainfall pattern, the records by the automatic rainfall recorder during a period of 22nd to 24th January, 1968 at the Navet Presbyterian School Gauging station in the watershed are selected as a basic rainfall pattern. The records indicate daily rainfall 3.91 inches, equivalent to about 80 percent of the probable value, which shows similarity to the daily rainfall for 10 year probability at the Newland Estate. And the same duration of rainfall is used, and the modified pattern as shown in Table II-1 is adopted with the proportional allotment of the rainfall.

The calculation of the runoff based on the rainfall data is carried out by a study on the rainfall at the Navet Damsite, the Navet Presbyterian School, and the Pure River, each of which provides the automatic recorders. Runoff is obtained by preparation of unit hydrograph based on records at the Pure River Gauging Station (Watershed area: 7.4 square miles) adjacent to the irrigable area. The unit hydrograph is made by analysis of the Tatugami Method, based upon records by hourly variation of six representative rainfall data during 1965 to 1967 as well as the river discharge.

The hydrograph in the Division (F), the Navet River basin, is prepared by adjustment of the unit hydrograph in the Pure River basin because of the big differences in the catchment area and the length of the flow channel between the both basins. The hydrographs of the other basins are prepared by applying to the unit hydrograph of the Pure River basin. The peak discharge in each drainage basin is obtained by adding the hydrograph from each basin to the time lag of the flows, and the result is shown in Table II-2.

Turure Cut

The Turure Cut, the open earth canal of a 5.6 mile length, to intercept the surface stream flowing out from divisions (B) to (C), is to be established along the northern edge of the irrigable area. The capacity of the canal is shown in table II-2, which clarifies its capacity fluctuation influenced by the area of catchment basin and the confluences of the rivers from the basin.

The main road in the irrigable area shall be constructed on the bank at the low hill side of the Turure Cut.

Cocal Reservoir

The Cocal Reservoir used for storing flood water in the Divisions (D) to (G) and for irrigation water supply, shall be constructed in homogeneous fill type dam with maximum height of about 24 feet[1/] and length of 7.2 miles, and its maximum and minimum utilizable water level shall be 118.3 feet and 105 feet respectively. Total stored water shall be about 35,100 acre-feet (43,173 thousand cubic meters), and available stored water is estimated at about 33,800 acre-feet (41,574 thousand cubic meters) on the utilizable water level. About 65 percent of flood water flowing out from the basin shall be cut off and stored there in its peak time.

1/ 80 percent of the dike shall have a height of 16.3 feet.

The foundation of the dike is the impervious and well-compacted Bois Neuf Clay. The embankments of the dam shall be thrown up with the similar charactered soil distributing around the site, and the crest height shall be 126.3 feet. (T.G.R.) The paved road shall be constructed with asphalt pitch on the top of the dike and be utilized as the main road in the irrigable area.

An over-flow type concrete spillway shall be installed at the point of Bois Neuf of the Cocal Reservoir. The spillway shall be provided with flap gate and shall avail in draining flood with 20 percent increase against the rainfall for 100 year probability in the basin. The gate shall have a structure to make the flood drained without operation of the gate, concerning the flood for 10 year probability of the basic year for drainage. At the bottom of the dike , the concrete conduit shall be laid for water intake from the reservoir and for supply of irrigation water to the low-lying land of the Swamp elevation under 105 feet.

Nariva Regulating Reservoir

The Nariva Regulating Reservoir shall be constructed at the lower part of the swamp area and the excess water in the irrigable area and its adjoing watershed area shall be drained to Cocos Bay through this Reservoir by gravity drainage. The reservoir shall be separated from the irrigable area by the low embankment but be related to the area through the main drainage canals to be constructed between them. In the event that three-days rainfall in the irrigable area and its adjoining watershed area, can be drained for three days, the water level in the regulating reservoir can be kept at 99.60 feet (T.G.R.) and the amount of stored water will be 167,000 acre-feet (205,410 thousand cubic meters) in the case.

The foundation of the dike is the impervious and well-compacted Nariva Swamp Clay or Bois Neuf Clay, and the dike shall be built with the same charactered soils as the said clay which will be obtained by excavation of the drainage canals, and the crest height of the dike shall be 103 feet (T.G.R.). The earth canals shall be installed at the original ground of the regulating reservoir for feeding floods to the barrage.

Drainage Canal

To regulate flushing discharge of the rainfall in the irrigable area, notches shall be installed at ridges of fields with drainage capacity of 0.12 inch per hour in overflow depth 0.8 inch. The excess water in the irrigable area shall be caught into a drainage canal through the notches and conducted to the Nariva Regulating Reservoir. This drainage canal shall have capacity of 0.16 inch per hour and its cross-section shall be of 350 cubic feet per second (10 cubic meters per second) at maximum while fluctuated by drainage area. Furthermore, the drainage canal shall be used for irrigation as well, and the check works shall be made for controlling the water level when the water is distributed to the works shall be made for controlling the water level when water is distributed to the fields.

Barrage

The barrage with three gates 25 feet wide each shall be installed at the northern end of the Nariva Regulating Reservoir to conduct the excess water to L'Ebranche River for draining to Cocos Bay by the gravity system. The barrage shall be operated in corresponding to the sine curve of a twelve hour cycle at the mean high-water-level of spring tide, 99.5 feet (T.G.R.) and the mean low-water-level of neap tide, 96.7 feet (T.G.R.). The maximum discharge capacity of the barrage shall be about 9,200 cubic feet per second (260 cubic meters per second). The base level of the barrage shall be at a height of 88 feet (T.G.R.).

Estuary Features

L'Ebranche River shall be utilized in order that, through the barrage of the Nariva Regulating Reservoir, the excess water in the irrigable area and its relating watershed areas may be drained smoothly to the Atlantic Ocean by gravity system in correlating to the tidal level.

Runoff of Each Drainage Basin

In runoff analysis, the hydrographs of the watersheds of the L'Ebranche River and L'Ebranche Cut can be obtained in the use of the unit hydrograph

of the Pure River. The discharge at the L'Ebranche River Mouth can be composed by adding each hydrograph in the barrage, L'Ebranche Cut, and L'Ebranche River to the time lag of the surface streams and the result is shown in table II-3.

Table II-3

Maximum Discharge of Each Drainage Basin - in cubic feet per second

	Barrage	L'Ebranche Cut	L'Ebranche River
Maximum discharge of each drainage basin	9,181.8	296.6	2,270.7
Maximum discharge of L'Ebranche River mouth	9,181.8	70.6	529.7
		9,782.2	

Tidal Information

As for the tidal level at Cocos Bay of the L'Ebranche River Mouth opening to the Atlantic Ocean, the tide table and the observation records by the government of Trinidad and Tobago, 1968, are shown in table II-4.

Selection of River Mouth

The coast line of Cocos Bay has a violent wave breaker zone, and the movement of the sand is extremely great. It bears scouring tendency, but as a whole it may be considered to be stabilized. In order to maintain a river mouth as such by preventing the drift of sand at a certain spot of the coast line, it would be necessary to have a constant flow to flush the sand, or to construct a large training jetty.

The present Nariva River mouth is maintained by flows from inundated water in the swamp in the wet season, and by tidal discharge in the dry season. On the other hand, since a lower part of the irrigable area lies under the full surface water level, an inflow of tide shall be shut off by the barrages installed. By installation of the barrage, therefore, the tidal

discharge in the dry season will become unavailable and the maintainance of the river mouth will depend upon only the base flow. Under such conditions, the river mouth requires construction of the long training jetty for keeping the necessary mouth cross-section to drain the excess water without the base flow. The north end of Cocos Bay is recommendable for construction site of the training jetty in consideration of prevailing direction of drift sand. The left side of the jetty shall be constructed long enough and the right be protrued a little to protect the mouth from waves and drift sand.

Fortunately, in meeting these requirements, there exists natural jetty projecting out into the sea at the north end of Cocs Bay, where L'Ebranche River mouth opens under the protection by the jetty. L'Ebranche River has an independent basin and the river mouth can be maintained without any influence by development of the Nariva Swamp. If the river mouth is utilized for wasteway of the excess water from the project area, it is enough that only the preventive works shall be executed for erosion that will be caused by increasing discharge owing to the confluence of the rivers.

Nariva River Mouth

The Nariva River Mouth shall be utilized for drainage of flood water being introduced from the Cocal Reservoir during the construction works, but shall be closed for preventing the irrigable area from tidal damage after completion of the Nariva Regulation Reservoir.

L'Ebranche Cut

The peak discharge at the L'Ebranche Cut shall be 9,782.2 cubic feet per second, but the scale of the channels shall be decided on time fluctuation of the tidal level and water level in the Nariva Regulating Reservoir. As a result of the study, the objective discharge is estimated at 7,620.9 cubic feet per second (216 cubic meters per second) and the rectangular channels width shall be decided at 290 feet. The both banks shall be protected with steel sheet pile against erosion.

Table II-1 Schematic Rainfall Pattern

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Total
Observation Value on 1st Day										0.04	0.52		0.02										0.10		0.68
Modified Value										0.05	0.69		0.03										0.13		0.9
Observation Value on 2nd Day	0.02	0.02	0.12	0.52	0.78	0.08	0.08			0.05	0.20	0.32	1.20	0.52											3.91
Modified Value	0.03	0.03	0.16	0.65	1.00	0.10	0.10			0.70	0.25	0.40	1.54	0.67											5.0
Observation Value on 3rd Day			0.16		0.16																		0.02		0.34
Modified Value			0.38		0.38																		0.04		0.8
Total Value																									5.39
Modified Value																									6.7

Source: Records observed by automatic recorder at Navet Presbyterian gauging Station from 22nd to 24th January, 1968.

Table II-2 Maximum Discharge of Each Drainage Basins - in Cubic feet per Second

Basin Division	A	B	C	D	E	F	G	Development area	L'Ebranche River Basin
Basin Area 1/	1.85	4.17	13.90	5.33	13.05	65.60	37.64	17.18	14.13
Maximum Discharge of Each Drainage Basins	296.6	667.4	2,228.4	858.1	2,097.7	6,469.7	6,049.4	2,913.5	2,270.7
Discharge at confluence considering time lag	70.6	642.7	2,228.4	858.1	2,097.7	437.9	6,049.4	2,775.7	529.7
Maximum Discharge of Each Drainage Systems		Turure Cut 2,871.1			Cocal Reservoir 9,443.1 (Spillway 3,531.5)				
Discharge at junction of drainage system considering lag time		2,871.1			1,200.7				
		Nariva Regulating Reservoir 6,847.5 (Barrage Capacity 9,181.8)							

L'Ebranche River Mouth 9,782.2

Note: 1/ Unit of Basin area is square miles.

2/ Discharge hydrographs of above basins and drainage systems at confluences shall be composed in consideration of each transit time of flows of basins.

Table II-4 Tidal Information on Nariva Estuary

(Cocos Bay)

Position: Lat. 10° 24' N, Long 61° 02' W

Description	Average heights (ft) (By Tide Table) D.L (ft)	T.G.R. (ft)	Nariva River Mouth (by Government of T & T)
Mean higher high water (Heights at spring near the solstices)	4.4	100.3	100.0
Mean higher high water	3.9	99.8	99.5
Mean lower high water	3.5	99.4	99.1
Mean sea level	2.5	98.4	98.1
Mean higher low water	1.6	97.5	97.2
Mean lower low water	1.1	97.0	96.7
Mean lower low water (Heights at spring near the solstices)	0.5	96.4	96.1

Seasonal changes in mean level (ft)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.2	0.3	0.3	0.2

Chapter III

IRRIGATION SCHEME

General Descriptions

The project area consists of the Crown Lands of the Nariva Swamp and its surroundings, excepting private lands, and the gross area is about 26,500 acres (10,730 hectares), and the proposed irrigable area is about 11,000 acres (4,450 hectares) in the low-lying lands.

The irrigation scheme has close relation with the drainage scheme of the excess water in the area, and the main facilities such as the reservoirs, canals and so forth shall be used for both purpose. The following descriptions are given to the land and water utilization, the main irrigation facilities and the farm settlement.

Land Resources

Topography

The Nariva Swamp is surrounded by eastside slopes of the Central Range at the north west, by the hilly lands along the Rio Claro-Mayaro Poad at the south, by the coastal sand dune expanding from north to south and facing Cocos Bay at the east. The topographical features of the area show two aspects, the one in a high-lying land of a hilly mountainfoot area, and the other in a extremely plain swamp formed by alluvial action. The swamp area is mostly at elevation of 96 feet to 120 feet (T.G.R.) and inundated in the wet season. In the swamp area, there are two small island-like hilly lands such as the Sand Hill and the Bois Neuf Hill, and as a whole, the swamp is sloped down towards Cocos Bay. The wide swamp has some differences according to the elevation, and the vegetation varies according to present drainage conditions and soil characters.

Present Land Use

Most of the irrigable area, except the area developed in the Plum Mitan Rice Scheme, is undeveloped yet and even the developed area has not sufficient agricultural products due to deficiency of the irrigation and drainage facilities. The rice cultivation is temporarily conducted in the wet season, and only some water melons and tomatoes are planted in the dry season.

Soil

The existing soil classifications, soil distribution map, and descriptions on the soil groups for the irrigable area has been very helpful to this survey. The reconnaissance survay has been carried out for finding the land suitability to the irrigation and the soil conditions in the irrigable area. The representative soil series on Exhibit III-1 is obtained from the investigation on the soil texture, structure, color and humus with seven test pits dug. The results of the physical and chemical analysis on soil samples gathered from seven test pits also are shown in Table III-1, and these analyses have been made in the University of the West Indies on the following items; the measurement of pH values on wet soils and dry soils, the measurement of loss on ignition in oven dry soils, and the contents measurement on total nitrogen, organic carbon, sulphur, potash sodium, magnesia, lime, silica and alumina. In addition, the analyses have been made on phosphorus, cation exhange capacity, and total exchangeable bases.

From the results of these analysis and the data in the previous investigation, the soils in the irrigable area except the peat zone developed along the Nariva River at the backside of the eastern beach bank, can be found to have suitable soil characters and fertility preservability for cultivation of rice, maize and soybean. Judging from soil characters, soil distribution, and topographical conditons, the suitable land for irrigation is selected in the area under elevation of 110 feet (T.G.R.) excepting the area under elevation of 99 feet (T.G.R.) along the eastern

beach bank. The area excepted from the irrigation objective shall be utilized as a regulating reservoir for flood drainage.

Land Classification

In classifying the lands of the project area, two topographical conditions of the hilly land and the swamp area, and drainage conditions are considered as the most remarkable elements. The classified areas on soil series in the project area are shown in Table III-2. These areas are ramified into five groups shown in Table III-3 as the land classification on topography, drainage conditions, soil characters, and vegetation.

The grouped areas in the project area, 26,500 acres (10,730 hectares) are as follows. But the Macow Peaty-Clay in the soil series No.10 is omitted as an unclutivable land and the area in the group No.5 shall not be an objective of proposed development area because it has been utilized as the coconut plantation since before.

Land Classification	Group 1	Group 2	Group 3	Group 4	Group 5
Land Area (Acre)	-	21,295	3,349	1,912	-
Percentage	-	80.2	12.6	7.2	-

Most part of the project area, except the southern hilly lands, is an alluvial plain at elevation a little higher than the high tidal level. In the wet season, the inundation covers almost whole area, and in the dry season some part at comparatively high elevation becomes arid. The soil character is of strong acid heavy clay from top soil to lower layer containing no gravals. Giant aroids and giant sedges cover the most of the area, and only temporary cultivation is carried out around the Plum Mitan area at comparatively high elevation. Since most of the irrigable area will become uninundated after the development scheme is realized in the future, the land utilization scheme will be decided depending on the soil texture.

Land Utilization Scheme

The land utilization scheme according to the groups in the land classification is described as follows.

Land Utilization of Group No.1

The peat lies on the surface of the land, and the clay soil (partly sandy soil) in the subsoil. Judging from the topography and soil conditions, this area cannot be positively converted to the agricultural land but be used as the construction site of the Nariva Regulating Reservoir.

Land Utilization of Group No.2

Since the strong acid heavy clay soil exists from top soil to the deep subsoil, the careful attention is to be paid to irrigation, drainage and selection of introduced crops. This group occupies most part of the project area.

Land Utilization of Group No.3

The land is well drained but poor in water holding capacity. Since it is situated at high elevation, the water lifting is required and furthermore some soil improvement is indispensable for arable land utilization. Consequently, it shall remain as the green zone since it does not occupy large acreage.

Land Utilization of Group No.4

Most part of the land in this group has been already utilized, but the land productivity is not so high in general. A part inundated in the wet season can produce more benefit by drainage.

Land Utilization of Group No.5

The land in this group is the coastal dune and has been already utilized as coconuts plantation. Therefore, this group is omitted from the development objectives. As a result of the study of the soil texture on each group, the land utilization shall be made mostly on the lands of Group No.2 with its similarities, and partly to the lands of Group No.3 and No.4.

Water Resources

Natural River Flows

The irrigation water supply to the irrigable area shall be derived from the Cocal Reservoir having stored water of the natural flows of the Jagroma River, Navet River, Anho River, the total river basin of which occupies about 85 percent of the whole watershed area of the swamp. The annual water requirement accounts for about 40 percent of the natural flows of these rivers, and in the dry season or in their low discharge, the natural flow shall be utilized very effectively. The frequency of stored water in the reservoir utilization is 1.82 annually.

Though many rivers and creeks are flowing into the project area, the discharge observation is being conducted only on the Navet River which has the largest watershed in the project area. And yet the discharge observation has started very recently. Therefore, the effective data for long term is not available. It is possible, however, to make an assumption of discharge from the watershed utilizing the records at rainfall gauging stations in the project area and its surroundings.

Navet River

The Navet River, which originates from the Central Range and flows into the irrigable area, is the largest river with the basin, 65.6 square miles. It shall supply 54 percent of the supplemental water to the Cocal Reservoir.

In the upperstream of the river, the Navet Dam for municipal water services has been constructed already and has a storage capacity of 15,481 acre-feet (4,200 million gallons or 19,047 thousand cubic meters) with the catchment area, 7.0 square miles. There exists only one hydro-metero-logical station at the surrounding place of the project area.

Discharge observation of the Navet River has been conducted at two gauging stations, Damsite (catchment area 7.0 square miles, observation since 1961) and Cunapo Southern Road (catchment area 18.0 square miles, observing since 1967).

Other Rivers

Discharge observations of the Jagroma River and the Anho River, which shall flow into the Cocal Reservoir, have not been conducted and only the assumed discharges can be obtained from the rainfall records and the application of the runoff analysis on the Navet River basin. These rivers have the basin of 56.02 square miles, but their usefulness to water supply is much less than that of the Navet River due to little continuous effective discharge in the dry season.

Existing Water Use

The surface streams from the watershed are little utilized systematically, except the Navet River with 46.4 percent of the whole watershed area, and only at a part of surroundings of the Plum Mitan area, some water melons and tomatoes are in temporary cultivation by utilizing the intermittent streams in the dry season. It can be said, therefore, that effective utilization of water resources has not been made down to date. The cooperative water resources survey by the Government of Trinidad and Tobago[1/] and Canada[2/] has been carried out since 1967. In this series of survey, though various effective observation has been made, the data of them cannot be fully utilized in their statistic treatment due to the short observation term. Under the circumstances, the observation must be continued from now on.

Water Quality

The water quality investigation is conducted on water temperature, pH value, electric conductivity, and salinity for river water flowing into the swamp area from the watershed shown in Table III-1, stored water in the swamp and water of the Nariva River and L'Ebranche River with their mouths open to Cocos Bay. As the results of the study, as shown in Table III-3, the river water flowing into the swamp is judged to be harmless as

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1/ Water and Sewerage Authority, Trinidad and Tobago. (W.A.S.A.)

2/ M. M. Dillon Limited. Consulting Engineers.

irrigation water, but the small amount of condensed water stationed in the swamp, refered as No.W5 and No.W6, in the south east part of the irrigable area, will have baneful influence on the crops delicate to salinity, and therefore, fresh water shall be introduced to the areas in the dry season. Since both of the Nariva River and L'Ebranche River with their mouths open to Cocos Bay have the tidal compartment upto the considerable upstream, they cannot be utilized as the irrigation water resources.

Program for Water Use

Projected Cropping Pattern

The representative two cropping patterns for the dry and the wet season are selected according to the meteorological conditons. These patterns are decided in consideration of the following conditions, as meteological, soil, market, general economic and social conditons. Each cropping pattern is presented in Table III-5.

Table III-5
Projected Cropping Patterns

Crops	Wet Season (May to Oct.)	Dry Season (Dec. to Apr.)
Paddy	100%	50%
Soybeans	-	25%
Maize	-	25%
Total	100%	100%

The cropping patterns have relations with the water requirement, the scale of the reservoirs, and are the basis of calculation of irrigation benefit and repayment capacity for loan.

Consumptive Use of Water

Consumptive use by upland crops (Evapotranspiration) is composed of evaporation, and transpiration from the soil surface and leaves of crops

and the evapotranspiration can be calculated by the Penman Method on meteorological data.

For the evapotranspiration of paddy fields, seepage loss, 0.2 inches per day and the paddling water requirement, 7.87 inches per day are added to normal evapotranspiration. The net irrigation water requirement on the projected cropping pattern in 1961, the basic year for irrigation planning, is calculated as about 23.53 inches in the wet season, and about 22.98 inches in the dry season, as shown in Table III-6.

Farm Efficiency

About 65 percent of the water supplied to the turnout in the farms will be utilized for consumptive use by crops. The rest portion of the supplied water is considered as a loss in deep-seepage or on farm waste.

Conveyance Loss

The soil in the project area is heavy clay soil, whose permeability co-efficient is very small in N x 10^{-7} feet per second, but the seepage loss is indispensable in earth irrigation canal. And additional consideration is necessary for a loss from maintenance and operation of the irrigation system. Therefore, 15 percent of the supplied water at the diversion is considered as the seepage loss plus the operation loss.

Diversions and Deliveries

The consumptive use in the projected cropping patterns, the diversion requirement per month and per unit area in the basic year for irrigation planning of 1961 are calculated and shown in Table III-6. And the annual diversion requirements for each canal are indicated as follows.

Conveyance System	Net Irrigation Areas[1/]	Annual Irrigation Requirements
Plum Mitan Canal	1,700 acres	11,600 acre-feet
Bois Neuf Canal	6,000 acres	41,000 acre-feet
Ortoire Canal	1,300 acres	8,900 acre-feet
Total	9,000 acres	61,500 acre-feet

1/ About 10 percent of gross area is deducted for the roads and canals. (Refer to Appendix L page 19)

Cocal Reservoir Capacity

Water Balance

In both of the dry and wet seasons, the total amount of irrigation water shall be supplied from the Cocal Reservoir to the irrigable area of about 9,000 acres (3,650 hectares). This reservoir shall have the dual purposes to cut off the flood water and to store the effective river flow for irrigation. The detailed study is made on the relation between the amount of monthly water supply to the irrigable area and the volume of water storage in the Cocal Reservoir in the basic year for irrigation planning of 1961.

This study is made in calculation on correlation between rainfall and runoff and diversion requirements. The results of it are shown in Table III-7. In the basic year for irrigation planning of 1961, the Cocal Reservoir can supply annually to the irrigable areas with 25,700 acre-feet (31,611 thousand cubic meters) of water, which will be equivalent to approximate 40 percent of the annual discharge from the watersheds area relating to the Cacol Reservoir.

Reservoir Capacity

As shown in Table III-7, the net capacity of Cocal Reservoir can be found to be 26,600 acre-feet (32,718 thousand cubic meters) in the basic year for irrigation planning of 1961. The gross capacity of the reservoir is calculated by adding losses for sediments, evaporation and percolation, to the net capacity.

Sediments

Most part of the watershed of the irrigable area is covered with woods, excepting the estate area along the Plum Mitan Road, and the vegetation is luxuriant. In geological features, most of the area is covered with clay soil, except lime stone, quartzites and conglomerates distributed partially in the Central Range. Little distribution of sand, gravel, boulder can be found even in the river bed forming the valley. The sediments by river flow from the watershed are the drift clay soil carried by flood water

and the fact is accordant with the result of the soil survey on the irrigable area. A measuring station was established at the Navet Damsite in 1967 for the survey of the sediments in the Navet River, but the available data could not be obtained due to the short observation term. In case that the empirical value of the sediment amount, 340 cubic yard/year/square mile (100 cubic meters/year/cubic kilometers) is taken as the standard sediment to calculate the total sediment amount for 50 years of the economic analysis period, the relative amount is 1,300 acre-feet, 1,599 thousand cubic meters) which is obtained by being added to the value of the net reservoir capacity in decision of the gross reservoir capacity.

Evaporation

Evaporation from the stored water surface can be calculated by evaporation per unit area and reservoir surface area. The evaporation per unit area is computed on the data for 1967 to 1968 at the Navet Damsite by the Penman Method, which is applied to the calculation of the irrigation water requirement. The reservoir surface area is taken as the water surface area in case of a half of the effective capacity of reservoir. The evaporation in the insufficient water supply period from the middle of December to the end of May, shall be added to the reservoir capcity in determination of the effective capacity of reservoir. The relative amount will be 6,200 acre-feet (7,626 thousand cubic meters).

Percolation

In consideration of the permeability coefficient, percolation from the dike body and its foundation will be approximate 3 percent of the total amount of the net reservoir capacity and evaporation; it will be about 1,000 acre-feet (1,230 thousand cubic meters). As the results of the foregoing calculations, the effective capacity of reservoir, (total of the net capacity, evaporation and percolation) will be 33,800 acre-feet (41,574 thousand cubic meters) and the gross reservoir capacity be 35,100 acre-feet (43,173 thousand cubic meters).

Main Facilities

Cocal Reservoir

The reservoir shall be constructed with the low banks at a length of 7.2 miles, running from the starting point of the Jagroma Cut and along a land at elevation of 110 feet (T.G.R.) to Bush Bush of the high-lying land through Bois Neuf, and shall store the floods from the watersheds in the wet season to supply irrigation water.

The reservoir shall have about 33,800 acre-feet (41,574 thousand cubic meters) of the effective capacity and shall supply necessary water for the whole irrigation area of 9,000 acres (3,650 hectares) in the dry and wet seasons. Furthermore, the crest of the dike shall be utilized as the main road in the area. The elevation of the full water surface will be 118.3 feet (T.G.R.) which is obtained from the curves shown on Exhibit III-2 on water level and storage capacity in the reservoir. The curves on Exhibit III-2 show the water storage capacity at each water level in the reservoir as follows.

Water Level	Storage Capacity
Over 110 feet (T.G.R.)	28,700 acre-feet (35,301 thousand cubic meters)
Between 110 feet and 105 feet (T.G.R.)	5,100 acre-feet (6,273 thousand cubic meters)
Under 105 feet (T.G.R.)	1,300 acre-feet (1,599 thousand cubic meters)
Total	35,100 acre-feet (43,173 thousand cubic meters)

Jagroma Outlet Works

This is outlet works for water intake from the Cocal Reservoir to the Plum Mitan Canal and the water intake shall be made by slide gates. The water shall be supplied to an area of 1,700 acres (690 hectares) of comparatively high elevation in the swamp.

This intake shall have the round cross-section with 30 inches of internal diameter possible for the maximum intake capacity of 52 cubic feet per second (1.5 cubic meters per second)[1/] and provide with gates for discharge regulating. The Plum Mitan Canal shall have a length of 30 miles and run along an area at elevation 110 feet (T.G.R.) to be connected with the north end of the Nariva Regulating Reservoir. Though the peak capacity of the Plum Mitan Canal will fluctuate according to size of irrigable area, the maximum capacity is estimated at 52 cubic feet per second.

Bois Neuf[2/] and Ortoire[3/] Outlet Works

The Bois Neuf Outlet Works shall be constructed to effectively use the volume of water storage under 110 feet water level (T.G.R.) in the Cocal Reservoir, and the water intake shall be made by slide gates to supply water to an area of 6,000 acres (2,340 hectares) in the lower swamp area under elevation 105 feet (T.G.R.)

The water taken from the reservoir shall be conducted along the elevation of 105 feet (T.G.R.) by the Bois Neuf Canal, which shall be connected with the Petite Poole Cut. The Bois Neuf Canal shall have the peak capacity[4/] of 126 cubic feet (3.6 cubic meters) per second and about 5.9 miles long.

Ortoire Outlet works with peak capacity[5/] of 17 cubic feet per second shall be constructed at two places on the bank between the Jagroma Outlet

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1/ The conveyance capacity is decided in a manner that considering peak consumption, extra 30 percent is added to the maximum monthly mean water requirement shown in Table III-6.

2/ In order to utilize the low level water in the Cocal Reservoir, the outlet works to be constructed at the point between Bois Neuf and Bush Bush shall be called the Bois Neuf Outlet Works.

3/ The outlet works for direct water intake from the Cocal Reservoir shall be called the Ortoire Outlet Works.

4/ The conveyance capacity is decided in a manner that considering the peak consumption, extra 30 percent is added to the maximum monthly mean water requirement in Table III-6.

5/ The conveyance capacity is decided in a manner that condiering the peak consumption, extra 30 percent is added to the maximum monthly mean requirement shown in Table III-6.

Works and Bois Neuf, in order to divert the water directly from the Cocal Reservoir to the irrigable area.

Gravity Distribution System

The diverted irrigation water from the Cocal Reservoir or the main conveyance system shall be distributed by the secondary canal to irrigable block of 12 acres (4.9 hectares) at the terminal area. The peak capacity of the secondary canals will fluctuate according to the area, to which water is distributed by the secondary canals. And since the secondary canals are planned to be used for drainage as well in the field, the capacity will be regulated by the surface flow from the drainage area.

The irrigation water shall be supplied by the gravity distribution system in both of the main and the secondary canals. The earth canals shall be constructed in most part of both in consideration of the permeability coefficient of the ground (N x 10^{-7} feet per seond). The turnouts, the check works and other structures shall be installed to divert the water or to regulate the discharge in the canal systems.

Turnouts

The diversion measuring instrument in the irrigation scheme shall be placed with a device that the water amount obtained by the users in the distribution system can be controlled and measured. The turnouts from the Cocal Reservoir to the canals shall be designed to dissipate energy of the static head in the reservoir and the water shall be taken from the reservoir with pipes. The turnouts shall be composed of a combination of gates for discharge control and parshall flumes for discharge measurement, be provided with impact box for the energy dissipation, and be connected with the open canals.

The turnouts from the main canals to the secondary canals shall be installed in combination of cast iron slide gates and the parshall flumes. The turnouts at the points from the secondary canals to the farm ditches shall be equipped with notches and stop-logs for discharge control.

Checks

In case that the discharges are insufficient for diversion in the main and the secondary canals, the check shall make it possible to increase water depth upto the level necessary for diversion at the turnouts. The reinforced concrete structures and the steel gates shall be installed for this purpose.

Farm Settlement

Preparation for Farm Settlement

The farmers' settlement shall be commenced when the first stage construction of irrigation and drainage facilities will be completed. Consequently, by the time a year before completion of canal construction of the first stage, the constructions of the farmers' houses, industrial and public facilities should be completed by the Development Authority, while the qualified persons for settlement should be selected by the Government of Trinidad and Tobago. Furthermore, the qualified persons to settlement shall be trained on cultivation techniques of paddy, soybean and maize, and on operation of the large agricultural machinery, if necessary.

Farm Managing Scale

Farm size shall be 14 acres (5.7 hectares) per household which is necessary for obtaining the agricultural income equivalent to earnings of those who work in urban areas and for mechanized farming by use of tractors and combines. The acreage shall be divided into two irrigable blocks; 2 acres (0.8 hectares) for home stead and 12 acres (4.9 hectares) for others in consideration of future intensive farming. The former block shall be distributed within the villages, and the intensive farming for horticulture and others shall be planned to follow the increasing labour force in the area and to meet the demand for the vegetable in the urban area.

For references, irrigable block size at the existing village community

are 15 acres (6.1 hectares) per household in Polder Settlement in Guiana and about 12-86 acres (4.9 - 34.8 hectares) in Pissayambo irrigation project for the cultivated land in Ecuador, and 20 acres (8.1 hectares) for dairying at stage of full development and 10 acres (4 hectares) for tree crops in the Crown land in Trinidad and Tobago. Furthermore, the paddy cultivation in Surinam is operated in much larger scale and at a lower production cost.

Cropping Pattern

The paddy cultivation by settlers will be fully adoptable to the whole irrigable area in the wet season by complete drainage systems as well as water supply by irrigation facilities. Since the natural surface flow are not sufficient in the dry season, the cultivation of soybean and maize by upland irrigation is planned for 50 percent each for the whole area. In this cropping pattern, however, the benefit-cost ratio is found unfavourable. As a result of study[1/], the following is decided; in the first stage, the double cropping of the paddy shall be carried out for the whole area and in the second stage, paddy for 100 percent in the wet season, and paddy for 50 percent, soybean for 25 percent and maize for 25 percent shall be cultivated in the dry season.

Village Structure

The village structure shall be formed in a "Gathered Type" of settlement, and 3 villages comprising 640 households shall be planned with 200 households in the central village in Plum Mitan, 220 households each in the two villages; one place near by Bois Neuts and the other place in the irrigable area.

Various industrial and public facilities shall be constructed in these villages. Necessary lands for public facilities shall be secured in the project plan but the construction cost of these facilities shall be disbursed from the general budget of the Government of Trinidad and Tobago, and be excluded from the construction cost of the project.

1/ Refer to Appendix L, Project Economy.

Table III-1 Chemical Analyses of Soils

Soil Series No.	Sample No.	Horizon	PH (1:2.5) Wet Soil H_2O	PH (1:2.5) Wet Soil N.Kcl	PH (1:2.5) Air-dry Soil H_2O	PH (1:2.5) Air-dry Soil N.Kcl	Loss on Ignition (500°C)	Total Nitrogen	Organic Carbon	Sulphur S	Potash K_2O	Sodium Na_2O	Magnesia MgO	Lime CaO	Silica SiO_2	Alumina Al_2O_3	Phosphourus P (p.p.m in Oven-dry Soil)	Cation Exchange Capacity (m.e per 100 Gm. Oven-dry Soil)	Total Exchangeable Bases (m.e per 100 Gm. Oven-dry Soil)
	1-1	A_1 Top Soil	5.6	4.5	5.3	4.3	12.3	0.30	2.5	0.0656	2.0	0.5	0.2	Nil	64.6	14.2	777	29.8	20.8
23	1-2	A_2 Sub Soil	5.0	4.0	5.0	4.0	5.3	0.10	0.9	0.0598	1.3	0.6	0.1	Nil	78.0	13.4	770	14.0	10.4
	1-3	B Deep Sub Soil	4.9	3.7	4.6	3.8	5.0	0.09	0.4	0.0884	1.5	0.7	0.1	0.1	78.0	12.1	478	17.1	8.8
	2-1	A_0 Surface	4.9	4.2	4.7	4.1	20.0	0.77	8.3	0.3134	1.7	0.5	0.2	0.1	42.5	20.3	650	43.6	22.9
8	2-2	A_1 Top Soil	5.3	4.4	5.0	4.1	9.7	0.24	2.4	0.1311	2.0	0.3	0.3	0.1	48.1	23.3	535	30.0	26.0
	2-3	A_2 Sub Soil	5.0	4.2	4.6	3.8	8.3	0.24	1.8	0.1299	2.1	0.4	0.2	Nil	50.9	24.6	254	31.9	23.1
	2-4	A_3 Deep Sub Soil	5.6	5.0	5.2	4.5	21.3	0.59	12.2	0.4548	1.4	0.4	0.2	0.5	42.4	23.3	565	45.0	37.1
	3-1	A_1 Top Soil	5.0	3.8	4.6	3.6	8.3	0.22	1.9	0.0876	1.2	0.4	0.1	Nil	63.3	16.0	536	14.7	3.9
19	3-2	A_2 Sun Soil	5.2	3.9	4.6	3.6	6.2	0.10	0.6	0.0155	1.4	0.4	0.1	Nil	61.8	17.9	330	13.9	3.4
	3-3	B Deep Sub Soil	5.2	3.9	4.9	3.6	5.0	0.07	0.5	0.0721	1.2	0.6	0.1	Nil	72.6	11.9	371	9.3	5.2
	4-1	A_1 Top Soil	5.6	5.2	5.5	4.8	13.3	0.41	3.8	0.1338	1.8	0.3	0.2	Trace	49.8	17.9	942	31.0	29.4
23	4-2	A_2 Sub Soil	5.1	4.0	4.8	3.8	8.6	0.23	1.8	0.0348	1.8	0.3	0.2	0.4	51.4	21.3	770	26.6	20.7
	4-3	B_1 Deep Sub Soil	4.7	3.8	4.4	3.4	8.2	0.18	1.5	0.0954	1.9	0.3	0.2	0.2	49.3	22.6	382	26.1	15.4
	4-4	B_2 Deep Sub Soil	4.6	3.7	4.3	3.5	8.8	0.18	1.3	0.1696	2.0	0.3	0.2	Trace	55.7	20.5	382	26.1	14.1
	5-1	A_0 Surface	5.4	5.0															
10	5-2	A Top Soil	6.1	5.2	5.4	4.8	42.6	1.50	23.4	N.D	0.2	0.2	0.1	1.9	64.9	1.5	585	60.7	40.7
	5-3	B_1 Sub Soil	6.1	5.1	5.6	4.8	6.9	0.28	2.7	"	0.3	0.1	Trace	Nil	95.7	1.3	102	10.1	4.9
	5-4	B_2 Deep Sub Soil	6.2	5.6	5.0	4.2	1.7	0.04	0.3	"	0.3	0.2	Trace	Nil	96.0	1.3	101	5.1	Trace
	6-1	A_1 Top Soil	-	-	4.8	4.1	22.4	0.78	9.2	0.4263	1.8	0.4	0.1	0.1	36.0	19.2	1,628	39.0	22.5
9	6-2	A_2 Sub Soil	-	-	4.7	3.8	7.7	0.28	2.3	0.1063	2.2	0.5	0.2	0.1	45.0	24.0	458	31.8	21.3
	6-3	A_3 Deep Sub Soil	-	-	4.8	3.9	7.3	0.24	1.9	0.0918	2.2	0.5	0.2	0.1	43.5	24.6	410	36.0	21.4
	6-4	A_4 Deep Sub Soil	-	-	5.1	4.4	13.4	0.31	5.8	0.2484	2.0	0.5	0.2	0.1	45.0	22.9	497	41.4	25.3
	7-1	A_1 Top Soil	-	-	5.2	4.0	15.0	0.12	1.5	N.D	0.1	0.4	Trace	0.1	82.5	2.1	184	12.1	4.0
	7-2	A_2 Sub Soil	-	-	5.1	4.1	1.2	0.04	0.2	0.0177	0.1	0.1	"	0.1	88.5	2.1	81	5.0	1.3
41	7-3	B_1 Deep Sub Soil	-	-	5.9	5.3	0.8	Trace	Trace	0.0606	0.1	0.1	"	0.1	93.0	0.8	40	1.1	0.3
	7-4	"	-	-	6.9	6.1	1.1	"	"	0.0900	0.1	0.1	"	0.4	90.0	0.8	80	1.9	1.3
	7-5	"	-	-	7.1	6.4	1.0	"	"	N.D	0.1	0.1	"	0.2	93.4	0.8	80	1.1	1.0
	Mud		8.4	8.0	8.6	8.0	5.3	0.16	0.8	0.5327	1.8	1.7	0.2	0.3	66.8	12.3	488	15.0	

NB: 1. pH of the wet soils could not be measured on the Soil Series No.9(Sample 6) and Soil Series No.41(Sample 7) because 10 days elapsed from their sampling to analyzation.

2. Sample 5-1 could not be measured on detailes due to Grass Litter, which was undecomposed mulberry plants deposited on the top soil.

3. Mud is effusive products from active mud volcano in the Bois Neuf Hill.

4. ND: Not determined.

Table III-2

Soil No.	Soil Series	Soil Survey Area	Soil Developing Area in Project Area		Submerged Area	Omitted Area for Already Used or Uncultivable	New Development Area		Vegetation
			Soil Developing Area	Percent			Area	Percent	
		acres	acres	%	acres	acres	acres	%	
8	Bois Neuf Clay	5,653	5,653	9.1	1,802	-	3,851	14.5	Grass Land
9	Nariva Swamp Clay	7,920	7,895	12.8	2,048	-	5,847	22.0	Grass Land
10	Macaw Peaty Clay	1,612	1,612	2.6	939	673	-	-	Forest, Grass Land
14	Cocal Fine Sand	1,211	1,001	1.6	-	1,001	-	-	Coconut Plantation
19	L'Ebranche Sily Clay to Clay	5,875	2,978	4.8	-	2,903	75	0.3	Forest Partially Cultivated
23	Navet Clay	28,695	27,910	45.1	5,368	10,944	11,597	43.7	Forest, Grass Land
41	Las Lomes Fihe Sandy Loam to Loam	2,428	2,385	3.9	241	1,352	792	3.0	Forest Partially Cultivated
43	Princes Town Clay	3,194	1,924	3.1	-	1,924	-	-	Forest Partially Cultivated
47	Tarouba Clay	2,761	1,905	3.1	-	1,239	666	2.5	Forest Partially Cultivated
49	Ecclesville Silty Clay Laom to Clay	2,527	1,881	3.0	-	988	893	3.4	Forest Partially Cultivated
50	Jalparo Silty Clay to Clay	5,547	3,734	6.0	6	1,316	2,412	9.1	Forest Partially Cultivated
51	Tamana Clay	389	306	0.5	-	306	-	-	Forest
53	Mayaro Sand to Fine Sand	31	31	0.1	-	12	19	0.1	Forest
55	Brasso Clay	1,211	352	0.6	195	12	145	0.5	Forest
56	Marper Silty Clay and Clay	154	154	0.2	-	124	30	0.1	Forest
57	Canterbury Silty Clay	229	229	0.4	-	229	-	-	Forest Partially Cultivated
59	Moruga Loams	1,168	254	0.5	-	62	192	0.7	Forest Partially Cultivated
60	Mount Harris Catena Silty Clay	1,483	1,035	1.7	-	1,035	-	-	Forest Partially Cultivated
61	Mitan Fine Sandy Loams to Silty Clays	964	596	0.9	-	559	37	0.1	Forest
	Total	73,052	61,835	100	10,600	24,679	26,556	100	

Table III-3 Land Classification

	Relief & Geology	Drainage Condition	Soil Texture	Plant Growth
Group 1.	Low Swamp Area behind the natural beach bank in the eastern part.	Lower than the high tide level, and even in the dry season the drainage impeded, and in parts marshy lands exist.	Area represented by Macow Peaty clay in Soil Series No.10.	Areas where there is a tidal effect, and there is a dense growth of mangroves. And other parts are marshy plant area.
Group 2.	Extremely flat alluvial soil zone with the elevation being slightly higher than that of the high tide.	During the wet season, the area is inundated and partially arid in the dry season.	The area covers almost half of the Swamp Area represented by Clay Soil in Soil Series No.8,9, and 23.	Low-lying land covered with giant aroid and giant sedges, and forestery high land. Partially cultivable.
Group 3.	The prominent hill situated in the low flat area of the group 2, and low hilly land.	Drainage-free high lands.	Mostly Clay or Loam in Soil Series No.41, 50, 55 and only Sand Soil in Sand Hill.	Area covered with thick forest and partially cultivable.
Group 4.	Gently sloped mountain foot of the Central Range and the hilly lands in the southern part.	Imperfect drainage, but will dry up in the dry season.	Clay or Loam in Soil Series No.19, 43, 47 and 49 and mostly Humus Clay.	A portion of the land is used by estate owners. And others are abandoned forest.
Group 5.	Beach dune running from north to south along Cocos Bay.	Drainage free.	Soil in Soil Series No.14.	Utilized as the coconuts plantations.

Table I-7 Water Quality Data

Measurement Location No.	Survey Location	Survey Date	Water Temperature (°C)	pH	Electric Conductivity (μv/cm)	Salinity (ppm)	Remarks
W 1	Midstream of Cuche River	24th 3. 69	26	6.6	1,300	300	Droughty state at weir site in Cocoa Estate.
		9. 4.	29		1,800	440	
W 2	Jagroma	24. 3.	29		1,100	250	Stagnent water at the end of upstream of the canal of Plum Mitan Gate.
		10. 4.	30		1,100	250	
W 3	Downstream of Cauque River	10. 4.	27	7.1	1,900	460	Before confluence with canal at upstream of Plum Mitan Gate.
		13. 4.	28		1,500	350	
W 4	Midstream of Nariva River	25. 3.	27		20,000	10,000	At the back of Coconut Plant.
W 5	Kernanham	25. 3.	37		4,300	1,600	Stagnent water in ditches at the terminal point of the road running in the development area.
W 6	Kernanham	25. 3.	36	5.5	3,300	1,150	Stagnent water in trench, at 100m off from Beach Bank, of the road running in the irrigable area.
		13. 4.	28		4,000	1,500	
W 7	Downstream of Navet River	27. 3.	25		1,200	270	After confluence with a tributary.
W 8	Upstream of Bios Neuf River	27. 3.	25		1,100	250	Nearest to Bois Neuf Hill.
W 9	Plum Mitan	9. 4.	29	6.4	1,400	320	Stagnent water in the canal, and the same location as soil sampling No.6.
W10	Plum Mitan	9. 4.	29	7.4	2,000	500	Stagnent water in the canal, and the same location as soil sampling No.2.
W11	Midstream of L'Ebranche River	10. 4.	30	7.5	22,000	11,500	Cross point of the L'Ebranche River with the Eastern Main Road.
W12	L'Ebranche River Mouth	13. 4.	28	7.9	25,000	13,000	At the ferry 200m upper from River Mouth.
W13	Dabllon Bason	13. 4.	28	7.1	2,800	720	Swamp water in Dabllon Bason.
W14	Downstream Nariva River	13. 4.	28	7.2	25,000	13,000	At the Nariva River Bridge.

Table III-6 Estimation of Net Irrigation Requirement and Irrigation Water Requirement in 1961

Unit: inch

		First Crops							Second Crops							Total
		May	Jun.	Jul.	Aug.	Sept.	Oct.	Sub-total	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	
Irrigation Requirement(A)	Paddy	7.87	10.61	10.84	10.95	10.48			7.87	10.09	10.64	10.12	11.90			
	Upland									2.64	4.44	4.52	5.70	1.85		
Monthly Effective Precipitation(B)	Paddy	0.96	5.35	7.72	5.22	7.97			*6.48	2.63	3.30	0.62	1.67			
	Upland									*1.94	3.67	0.88	2.20	*0.45		
Net Irrigation Requirement(C)	Paddy	6.91	5.26	3.12	5.73	2.51			1.39	7.46	7.34	9.50	10.23			
	Upland									0.70	0.77	3.64	3.50	1.40		
	Weighted	6.91	5.26	3.12	5.73	2.51		23.53	0.70	4.08	4.06	6.57	6.87	0.70	22.98	46.51
Irrigation Water Requirement																
Farm Head Gate Requirement (D)	Paddy	10.63	8.09	4.80	8.82	3.86			2.14	11.48	11.29	14.62	15.74			
	Upland									1.08	1.18	5.60	5.38	2.15		
	Weighted	10.63	8.09	4.80	8.82	3.86		36.20	1.07	6.28	6.24	10.11	10.56	1.08	35.34	71.54
Diversion Requirement(E)	Paddy	12.51	9.52	5.65	10.38	4.54			2.52	13.51	13.28	17.20	18.52			
	Upland									1.27	1.39	6.59	6.33	2.53		
	Weighted	12.51	9.52	5.65	10.38	4.54		42.60	1.26	7.39	7.34	11.90	12.43	1.27	41.59	84.19

Note: Irrigation Requirement(A) : See Table H-8
Monthly Effective Precipitation(B) : See Table H-12 for upland fields. See Table H-13 for Paddy fields.
Net Irrigation Requirement(C) : (A) - (B)
Irrigation Water Requirement
Farm Head Gate Requirement(D) : (C)/0.65 0.65; Irrigation Efficiency
Diversion Requirement(E) : (D)/1-0.15 0.15; Conveyance ross

Chapter IV

LIVESTOCK SCHEME

General Description

Livestock breeding is not operated in the project area at present, except that a few cattle are bred at the surrounding area of Plum Mitan and a tiny scale of beef buffalo breeding is carried out at the estate along the southern coast part of the Manzanilla Mayaro Road in the project area.

On the other hand, Trinidad and Tobago annually imports the beef worth TT$7.0 millions[1/], which accounts for 8 percent of the total food imports of the country. (About 60 percent of the imported beef is from New Zealand.)

The dairy farms have been already expanded by the Crown Land Scheme, which will be able to cover the domestic consumption of the milk in the future. In the Nariva Swamp development project, therefore, a beef cattle breeding is planned.

Preparation of Breeding

Land Use

The watershed division (G) in hilly land at the south of the irrigable area consists of rolling lands at elevation from 120 to 250 feet (T.G.R.) and is almost covered with woods. The soil of the area is almost covered with woods. The soil of the area is clay soil and partly ill-drained.

1/ Refered to the trade statistics in 1966.

Under the circumstances, the beef cattle breeding is planned in view of the effective land use and marketing. Reclamation, however, shall be made to an area of 7,400 acres (3,000 hectares), about 50 percent of the total area, 15,500 acres (6,280 hectares), while location of the reclaimable land shall be selected in consideration of distribution of shadow trees and other condition such as transportation, communication and so forth, and the final decision for the area shall be made by topographical survey in the near future.

Land Reclamation

The reclamation shall be carried out to the undulate hilly lands and clear forest shall be remained not to be ploughed for protection of eroding of the top soil (almost clay soil), and after cuttings, up-rootings and bush clearings shall be executed, the top soil shall be crushed by the hooves of introduced cattle. Giant trees in the dense forest shall be uprooted by explosions for land clearance.

The reclamable area is not suitable for pasture cultivation by gravity irrigation from the Cocal Reservoir, due to hilly lands at high elevation. Consequently, the pasture shall be cultivated by non-irrigation method prevailing at the other district in Trinidad and Tobago.

If the beef cattle breeding is introduced at the rate of a head per acre in view of the actual record of the other district in Trinidad and Tobago, 7,400 heads will be bred for the total reclaimable area, and benefit will be secured at about TT$1.28 millions annually.

Facilities

The roads construction is required for connecting with each grazing land which will be sporadically situated as a result of selection of the suitable location for grazing. As for the road net works, the main road is planned to start from Cassadoux Trace, run eastward and connect with the Lasall Road after passing along the Cocal Reservoir, and the branch lines are planned to run in dendritic direction after starting from the Rio Claro-Mayaro Road. (Exhibit I-1 General Plan)

A drinking water for beef cattle shall be supplied by water from the municipal water works which exists along the Rio Claro-Mayaro Raod. And then, water shall be distributed to each grazing land. Simple shelters[1/] shall be built around the water places in each grazing land for cattles.

Beef Cattle Breeding

Beef cattle breeding shall be carried out in grazing lands of about 7,400 acres (3,000 hectares) except the woods and wind belts sporadically existing in the area of about 15,500 acres (6,280 hectares).

Operation System

In consideration of special features of the project area, the beef cattle breeding shall be operated by estate system, national or private, and not by a small private farm system. In other words, the establishment of infrastructures such as roads, water supply facilities (26.42 gallon/day/head or 0.12 cubic meter/day/head) and pasture lands shall be made by the Authorities control and the livestock farming including introduction of cattle shall be operated by each estate.

Grazing System

A scale of the herd shall be decided depending on topographical condition and growing state of cattle. Generally, during a breeding season, a herd shall comprise about 30 to 50 heads of cows and the same heads of calves, and during raising periods, 100 heads or some hundreds shall group in a heard for grazing all day and night. Therefore, pens will not be required, but shelters in paddock style shall be built at proper place around the grazing lands for prevention of cattle's runaway.

1/ Simple wooden house built with roof and panels.

The wind belts shall be set up in utilizing the existing woods, and the width of them shall be about 60 to 90 feet and the interval of each wind belt be 600 feet.

The location of the estates and the road net works cannot be shown in the map at present because the detailed topographical map is not available for the reclaimable area. Therefore, it is necessary to decide the details of the livestock scheme by further field survey and completion of the detailed topographical mpas which shall be conducted in the near future. As mentioned above, the grazing area suitable for beef cattle breeding is different from the irrigation area, and only the rough sketch on the scheme is available at present.

Chapter V
PROJECT COSTS

General Description

The project plan consists of two staged developments by irrigation and drainage on the low-lying swamp part and by reclamation on the southern hilly part. The project costs are spent in process of each stage of the construction works. Interest during the construction period is excluded from the project cost but contingencies, engineering fee and administration cost are included in it.

Construction schedule

The irrigation aspect is divided into stage I and II, each of which is a 5-year construction period. The construction schedules of various structures in stage I and II of the irrigation aspect are shown in Table V-1 and V-2. The livestock aspect of a 5-year construction works is scheduled to start at the same time when the irrigation aspect enters its stage II.

Construction cost

Direct construction cost

The direct construction cost is obtained by totalling various construction costs provided for the project plan. The contractor for the project construction and the suppliers for the construction equipments shall be decided by international tender favourable for the project.

The costs of plant and equipments provided by the suppliers are included in the construction cost. In the permanent equipment cost are the costs such as marine freight, inland transportation, installation and trial operation of equipment included, but customs duties on the imports of equipments and materials are exclusive. The construction cost is composed of local currency and foreign exchange components on the assumption that the supplies of major equipments and materials will be carried out by overseas supplier.

Total Construction Cost

To a total cost of irrigation aspect, indirect construction cost and contingencies should be added. The indrect construction cost includes the fees and charges such as engineering, inspection and administration. The contingencies are necessary as an allowance for unit price, project quantities and other unexpected expenses. Therefore, 25 per cent of the total cost is added to direct costs. A total of the estimated irrigation cost in Stage I and II is shown in Table V-4 and V-5. The reclamation cost is estimated at TT$320 per acre or US$400 per hectare (refer to Chapter VI, Livestock Aspect, Projects Inputs and Outputs of Beef Cattle) for 7,400 acres (3,000 hectares) of Project area. Summary of construction cost of the whole project are shown in Table V-3 collectively.

Table V-3

Summary of construction cost Unit: TT$1,000

		Foreign Exchange	Local Currency	Total
Irrigation Aspect				
Stage I	Construction Cost	2,270	2,830	5,100
	Land Improvement Cost	-	644	644
	Sub-total	2,370	3,474	5,744
Stage II	Construction Cost	4,370	4,800	9,170
	Land Improvement Cost	-	1,400	1,400
	Sub-total	4,370	6,200	10,570
	Total	6,640	9,674	16,314
Livestock Aspect		-	2,400	2,400
Grand Total		6,640	12,074	18,714

TABLE V-1 CONSTRUCTION SCHEDULE FOR 1ST STAGE

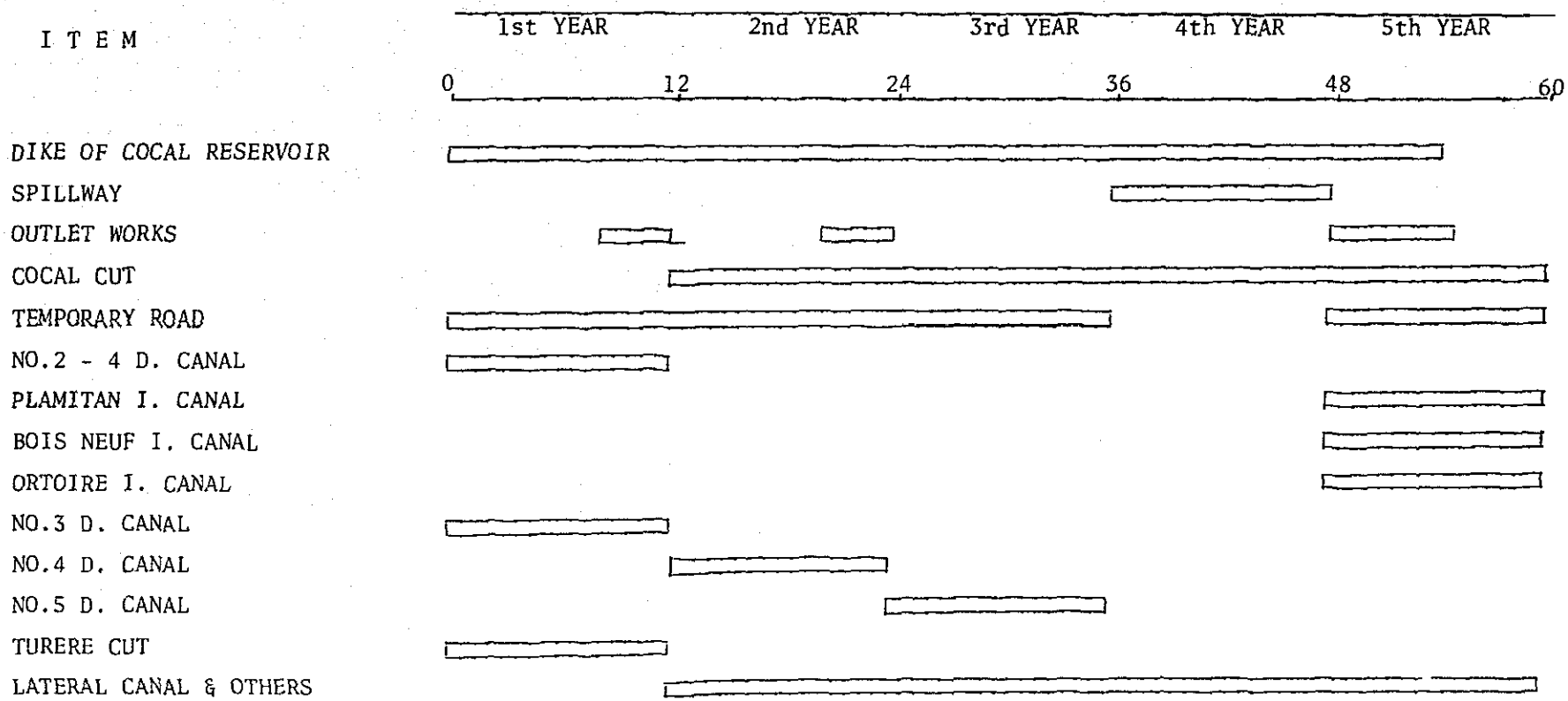


TABLE V-2 CONSTRUCTION SCHEDULE FOR 2nd STAGE

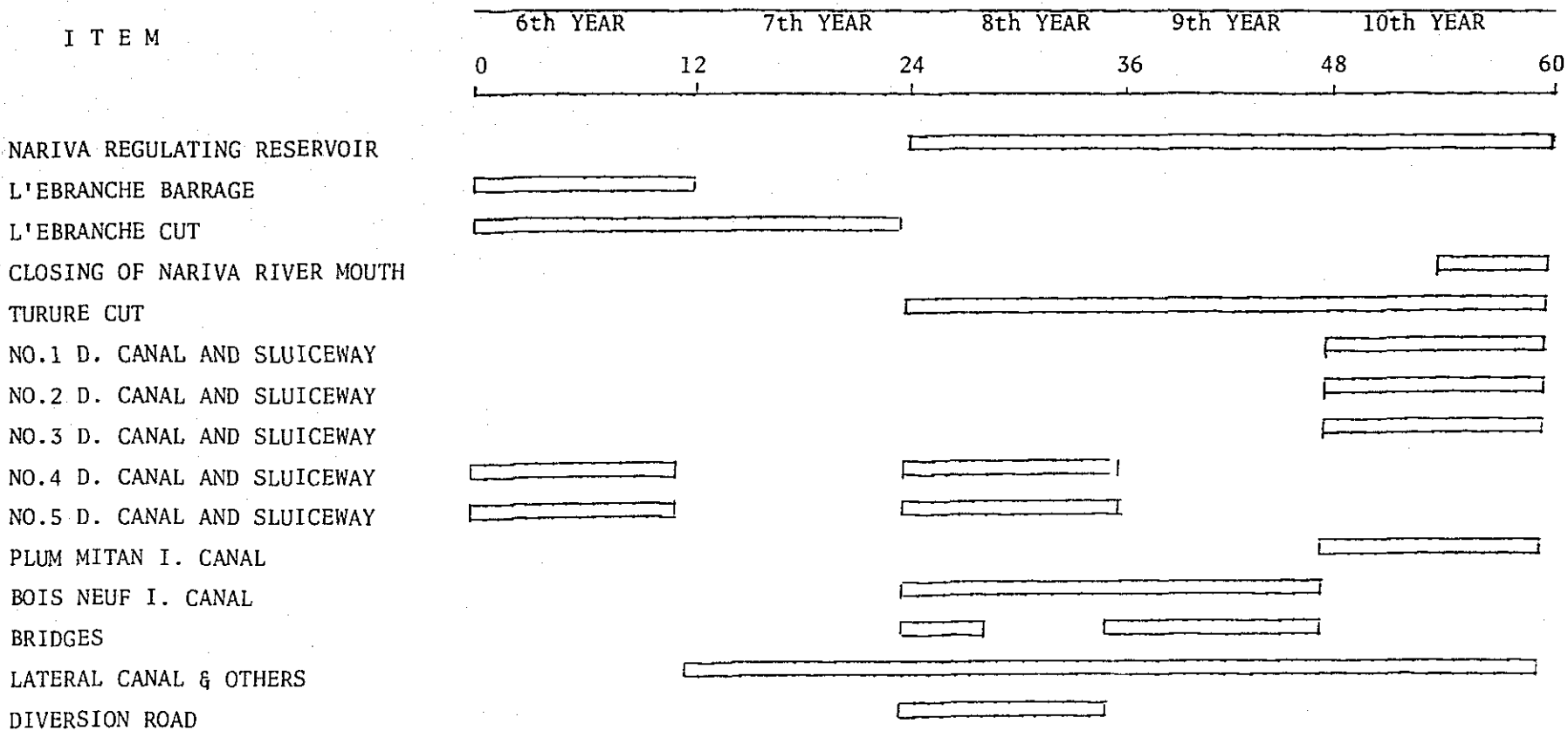


TABLE V-4 CONSTRUCTION COSTS (1st STAGE)

Item	Unit Price	Amount	Total Cost
Temporary Road	$1,390/100^{FT}	15,000^{FT}	208,500
No.2 D. Canal	$ 840/100	3,200	26,880
No.3 D. Canal	$ 950/100	3,100	29,450
No.4 D. Canal	$ 950/100	3,700	35,150
Turure Cut	$13,980/500	1,500	41,940
Cocal Reservoir	$ 5,160/100	38,000	1,960,800
Spillway	$500,000/each	1	500,000
Outlet Works	$ 15,000/each	4	60,000
Cocal Cut	$ 4,650/100	11,500	534,750
Plum Mitan I. Canal	$ 140/100	9,800	13,720
Bois Neuf I. Canal	$ 1,110/100	6,800	75,480
Ortoire I. Canal	$ 100/100	19,700	19,700
No.3 D. Canal	$ 950/100	7,900	75,050
No.4 D. Canal	$ 950/100	7,000	66,500
No.5 D. Canal	$ 950/100	7,200	68,400
Lateral Canal & Others	$ 161/acre	2,250^{acres}	362,250
Sub-total			$4,078,570
Contingencies (10%)			407,857
Engineering & Administration (15%)			611,785
Total			$5,098,212
		Rounded to	TT$5,100,000

TABLE V-5 CONSTRUCTION COSTS (2nd STAGE)

Item	Unit Price	Amount	Total Cost
Nariva Regulating Res.	$3,290/100^{FT}	52,500^{FT}	1,727,250
L'Ebranche Barrage		1	270,000
L'Ebranche Cut	$35,390/100	7,200	2,548,080
Closing of Nariva River		1	15,000
Turure Cut	$13,980/500	28,000	782,880
No.1 D. Canal	$ 740/100	5,700	42,180
No.2 D. Canal	$ 840/100	9,700	81,480
No.3 D. Canal	$ 950/100	10,100	95,950
No.4 D. Canal	$ 950/100	10,700	101,650
No.5 D. Canal	$ 950/100	10,500	99,750
Sluice ways	$30,000/each	5	150,000
Bridges	$ 8,000/each	9	72,000
Plum Mitan I. Canal	$ 140/100	5,700	7,980
Bois Neuf I. Canal	$ 1,110/100	24,400	270,840
Lateral Canal & Others	$ 161/acre	6,173^{acres}	993,853
Land Expropriation		1	12,000
Diversion Road	$ 1,390/100	4,400	61,160
Sub-total			$7,332,053
Contingencies (10%)			733,205
Engineering & Administration (15%)			1,099,807
Total			$9,165,807

Rounded to TT$9,170,000

Chapter VI
PROJECT ECONOMICS

General Description

The Nariva swamp agricultural development consists of two schemes. One is the irrigation and drainage scheme on the low-lying swamp area covering 9,000 acres (3,650 hectares). The other is the beef cattle raising scheme on the southern hilly area covering 7,400 acres (3,000 hectares). The summary is mentioned in Table VI-1.

Paddy fields developed by the irrigation and drainage scheme will be cultivated by 640 farming households to be settled in the irrigable area. The allotted land area will be 14 acres (5.67 hectares) per farming household. The beef cattle raising will be operated in a few pastures by either the government or private estate system.

The construction cost for irrigation and drainage scheme is comparatively high in view of topography, watershed, rainfall and so forth in the irrigable area, and its benefit will be evaluated on the basis of unit prices of the crops which are substitutes for the imports, and the investment efficiency is not high. Therefore, a foreign exchange component is expected to be financed on soft-loan terms by the international financing agency. As a consequence of the development, the imports of cereals will be substituted by 41.5% of rice, 10.2% of maize, 22.9% of soybean, and 17.6% of beef imports will be self-sufficient.

Irrigation aspect

Irrigation area

The project area is a Crown land, a part of which is 500 acres (200 hectares) of the arable lands at the northern swamp area and is currently rented for the temporary use of farming households and the remaining acreages are left unutilized. The old irrigation facilities is to be replaced by this planning, and the old project area is included in the

area of the overall development plan together with the new reclaimable land.

Since the initial construction cost of the old facilities is not revealed and the current yield in the arable land is unstable, it is almost impossible to figure out their average annual value. Therefore, the both items are omitted from economic evaluation, and the whole area is considered as a new project having about 11,000 acres (4,450 hectares) of gross irrigable area. [9,000 acres (3,650 hectares) of net irrigable area]

Projected Crop Yields

In view of the drainage control of the excess water during the wet season, the supplemental water supply and the preservation of soil fertility during the dry season, domestic market system and actual records of the imports of cereals in Trinidad and Tobago, paddy should be cultivated on 100% of the whole project area during the first crop season, and also paddy, maize and soybean should be cultivated on 50%, 25% and 25% respectively of the whole project area during the second crop season.

In the final stage of the irrigation scheme, an average yield of each crop per hectare, unit price and income are shown in Table VI-2. The decision of the unit price is based upon the import prices of cereals. The planned net income is expected to amount up to TT$202 per acre (US$253 per ha).

Annual benefit

In an effort to attain the projected yield worth TT$202 per acre (US$253 per ha), a 5-year period is required for agricultural vocational training of farmers and diffusion of agricultural techniques. Therefore, time lag in 50 years of economic analysis period is discounted on 7% interest rate. Annual benefit is expected to amount up to TT$144 per acre (US$178 per ha) on the above-mentioned conditions as indicated in Table VI-4.

Annual cost

For attainment of the level of the projected yields and net income, land improvement cost, enormous expenditure necessary for mechanization and

cooperative facilities should be added to the project cost. The cost of public facilities (for example, village office) is also required for farmers settlement on extensive land.

The cost per acre of these items, executing body and financing source are shown in Table VI-5.

Table VI-5

Cost and financing

	Total	Per acre	Body	Financing source
Project cost	14,270,000	1,583	Development Authority	International Financial Agency for F.e. Budget of Gov. for L.C.
Non-project cost	7,438,000		Cooperation	
Land improvement cost	2,044,000	277	- do -	Agricultural Development Bank
Mechanization cost	1,910,000	212	- do -	International Financing Agency
Cooperative facilities cost	3,484,000	387	- do -	Agricultural Development Bank
Public facilities cost			Government	Budget of Government

In the course of calculation of benefit-cost ratio, annual cost consists of the project cost (construction and replacement costs) and the land improvement cost (land formation, farm road and ditch) of non-project cost. The reason is why the annual cost for mechanization (operation and maintenance cost) is to be deducted from the income as each crop's production cost and the annual cost for cooperative facilities (the operation and maintenance cost) is to be evaluated by the farm gate price after being

deducted from the sales unit price of agricultural product. Since public facilities are, at any land, required for the settlement of local people, the cost of public facilities is not proper to irrigation project cost.

Annual cost amounts to TT$135 per acre (US$167 per ha) on the above-mentioned conditions as shown in Table VI-6.

As shown in Appendix M (Exhibit M-2), annual benefit and cost at a time of completion of the whole project area, however, calculated on the basis of present value at a time of completion of the works of stage I obtainable by discounting a 5-year actual cost of the works of stage II as mentioned below.

Summary of Annual Cost and Benefit

Unit: TT$

Annual Benefit

	Stage I	Stage II	Total
Irrigation Aspect	508,101	1,104,568	1,295,658
Livestock Aspect	-	242,777	242,777

Annual Cost

	Stage I	Stage II	Total
Irrigation Aspect	527,581	967,376	1,217,320
Livestock Aspect	-	158,500	158,500

Benefit-cost ratio

In case of 3%, 6% and 7% of interest rate, the benefit-cost ratio is shown in Table VI-7. The calculation method of 3% and 6% of interest rate is mentioned in Appendix M.

Table VI-7

Benefit-cost ratio

TT$ per acre (US$ per hectare)

Interest rate	Annual benefit	Annual cost	B/C ratio
i = 7%	144 (178.5)	135 (167.0)	1.06
i = 6%	150 (185.5)	120 (148.5)	1.25
i = 3%	172 (212.5)	80 (98.5)	2.16

Internal rate of return

Internal rate of return means interest rate in the relationship that annual cost is equal to annual benefit. The relationship of annual cost and annual benefit based on the change of interest rate is shown in Appendix M (Exhibit M-3). The internal rate of return is estimated at 7.4% as explained in Exhibit M-3.

Repayment capacity

The investment schedule by funds, which is required for the irrigation and drainage works as well as farm settlement, is summarized in Table VI-8. The investment is divided into three components financed by the budget of the Government for the fiscal year and by two loans of international financing agency (a foreign exchange component of construction cost and mechanization cost) and Agricultural Development Bank (costs of cooperative facilities and land improvement).

As shown in the investment schedule of Table VI-8, the farmers, first of all, should repay land improvement cost of non-project costs from their farming family income for the agricultural cooperation. (the components of mechanization and cooperative facilities costs will be deducted from the farmer's income on the decision of agricultural production cost and farm gate price.) Next, a part of the operation and maintenance cost of project costs should be repaid within their repayment capacity of the increased farming family income.

The repayment capacity is shown in Table VI-3 of farming family income. The total amount of the income per household is TT$4,584 per year, the amount of which will enable farmers to live on the same level of living standards as that in the urban areas. The amount of saving propensity is TT$917, or 20% of farmer's income. The limited amount of amortization is TT$366, or 40% of saving propensity. (TT$26.1 per acre, US$32.3 per ha)

Note: Worker engaged in agriculture-forestry:

TT$800 per day (on basis of public employee of the Government) x 25 days

..... TT$200

Annual income: TT$200 x 12 months

..... TT$2,400

Working number per household :

1.8 person (TT$2,400 x 1.8)

..... TT$4,320

Amortization

The land improvement cost, TT$227 per acre (US$280 per hectare) of non-project cost, should be repaid in cash by farmers for 70% of the cost. Hence the annual amortization amounts up to TT$280 per farming household. (TT$227 x 0.70 x 0.12590 x 14 acres = TT$280). As already mentioned, the limited annual amortization is TT$366 per household. Therefore, a surplus of farmer's income amounts to TT$86 per household after payment of the annual amortization for land improvement cost.

The operation and maintenance cost TT$11.8 per acre (US$14.5 per hectare) of irrigation project cost amounts up to TT$164 per household, a half of which will be collected as water charges. The repayment capacity of household is shown in Table VI-9. Consequently, the initail investment cost of the project cost cannot be amortized by farmer's income, and a foreign exchange component (46.5 per cent of total project cost) loaned by the international financing agency should be borne by the revenue of the Government for the amortization of TT$49 per acre (US$61 per ha).

A local currency component of the project cost should be disbursed by special account or sinking fund of the Government by the fiscal year according to the construction schedule as shown in Table VI-8. Because, after completion of the construction works, it is difficult for farmers to amortize the local currency component of the project cost. The project cost to be disbursed by the budget of the Government amounts up to TT$566,000 per year in Stage I of a 5-year construction period and TT$960,000 per year in Stage II of a 5 year construction period. According to the Draft Third Five-Year Plan 1969 - 1973, the total expenditure by the budget of the Government was estimated at TT$341.1 million for fiscal year 1968. Of this amount, the expenditure for the Nariva project by the Government accounts for 0.18% in Stage I and 0.31% in Stage II. The maximum amount of amortization for a foreign exchange component is TT$446,000 (US$223,000) in total, which will not incur financial pressure. Cooperative facilities and land improvement costs will be financed on 7% interest rate over 17 years including a 5-year grace period by Agricultural Development Bank. The annual amortization will be repaid to Agricultural Development Bank as shown in Appendix M (Table M-5 & 6).

Repayment of foreign exchange

Since all agricultural machinery are imported, the amount of which will be financed by foreign exchange of international financing agencies. The amount of amortization will decrease in proportion to long repayment years and low interest rate for the loan. The agricultural machinery is not considered as infrastructure but treated as well as construction machinery, and therefore agricultural machinery is to be procured by foreign exchange loan of international financing agencies.

The foreign exchange of construction and mechanization costs will be financed on a soft loan by international financing agencies. 46.5% of construction cost will be amortized on 3% interest rate over 25 years (including a 5-year grace period). Mechanization cost composed chiefly of agricultural machinery will be amortized on 3% interest rate over 17 years (including a 5-year grace period). Its payment schedule is shown in Appendix M-9, Table M-7 & 8.

The cooperative will collect the charges for use of agricultural machinery for its amortization, which will be repaid to the international financing agencies through Agricultural Development Bank.

The foreign exchange of construction cost should be, as shown in Appendix M(Table M-7), paid at an average annual amount of TT$314,160 (US$157,080) from the budget of the Government. This amount accounts for less than 10% of TT$4,487,672 (US$2,243,836) that is the annual saving of foreign exchange obtainable by substitution for the imports of agricultural products, and the project is considered very advantageous in view of national economic standpoint. (The maximum annual amortization appears on a period, the 11th year to the 25th year, after completion of the project). As already mentioned, the annual expenditure of the budget of the Government amounts up to TT$556,000 in Stage I of the this construction works and TT$960,000 in Stage II in local currency. This pre-investment is considered extremely effective for annual saving of TT$4,487,672 of the foreign exchange after completion of the construction works.

Table VI-10

Economy in F. E. Expenditure (After Completion of the project)

	Imports	Percentage of Substitution	Economy in F. E. Expenditure	
	TT$ (1966)	%	TT$	(US$)
Paddy	9,292,000	41.5	3,856,180	(1,928,090)
Maize	3,946,000	10.2	402,492	(201,246)
Soybean	1,000,000	22.9	229,000	(114,500)
Sub-total	14,238,000	31.5	4,487,672	(2,243,836)
Beef cattle	7,156,000	17.6	1,259,456	(629,728)
Total			5,747,128	(2,873,564)

Outline of payment schedule

The annual amounts of local currency and foreign exchange that the cooperative will amortize to Agricultural Development Bank and that the Government will do to the international financing agencies are shown are shown in Table VI-11, the summary of payment schedule. (Refer to Appendix M).

Livestock Aspect

A hilly land adjacent to the southern part of the Nariva swamp area is the Crown Land which is party utilized for wind break forest and others but generally remains unutilized for the agricultural field. This reconnaissance survey has not been executed to full extent, due to the reason why topographical map was not available for the area. The economic analysis of livestock aspect was not made with the same accuracy as that of irrigation aspect as a result of study pertaining to the present and future livestock production of Torinidad and Tobago. The operation of beef cattle raising is considered to be suitable in this area. The operation system of beef cattle raising is different from that of paddy cultivation, which is made in the form of the settlement in the irrigation and drainage area, and the whole land area is operated by a few estate systems after completion of reclamation works. The current economic analysis has been made on the assumption that the reclamation works for the whole area will completed in 5 years, but a development fund for opening this pasture is not financed by international financing agencies but by estates.

Livestock production

Milch Cows Production

The number of milch cows production is estimated at about 15,000 heads, 8% of which is raised by farming households having less than 4 heads in Torinidad and Tobago. A crossbreed and a pure breed will not probably exceed 1,500 heads. No reliable data is available for domestic consumption but about one tenth of local consumption is self-sufficient. The shortage of dairy products (including cheese and butter) equivalent to 22 million gallons (9.9 million liters) or milk is covered by the import, amounting up to TT$14 million annually.

The following is milk production and distribution plan in the Crown land. When 200 farming households enter full production of the planned target, 1.6 million gallons (7.2 million liters) of fresh milk will be produced. 200,000 gallons (0.9 million liters) out of 1.6 million gallons (7.2 million liters) of fresh milk will be distributed to the markets through the new Nestle plant, 3 small-scaled plants and reorganized plant. The rest of fresh milk amounting up to 1.4 million gallowns (6.3 million liters) will be consumed and retailed by farming households.

The dairy products equivalent to 3.2 million gallons (14.4 million liters) of fresh milk were imported in 1964, the annual amount shows increasing trend. The retail prices of sterilized milk are about TT$2.00 per gallon (TT$0.44 per liter) and powdered milk and condensed milk are about TT$1.45 per gallon (TT$0.32 per liter) of fresh milk respectively.

For milk self-sufficiency in the years to come, the Government owns about 571,000 acres (230,000 hectares) of land, in which there is undeveloped land considered suitable for agricultural development. A half of the land is sufficient for production of 13.2 million gallons (59.4 million liters) of fresh milk.

Beef production

About 2.6 million lbs (1.18 million kgs) of beef production is estimated to be meat of about 4,000 buffaloes. The annual imports of beef and pork amount up to 18 million lbs (8.16 million kgs) worth TT$9.5 million. For last three years, the import of chiken has been substituted by 10 million lbs (4.54 million kgs) of domestic chicken production. There is a room for the expansion of beef production, but the current production of chicken and pork exceeds domestic demand in Toridad and Tobago. The adoption of beef cattle raising on hilly land, which is located close to the Nariva Swamp area, is made by the reasons such as the sbubstitution for the imports and domestic marketing. After completion of the project, yearly production will be possible for 7,400 heads of beef cattle, i.e., 2 millions lbs (0.91 million kgs) of meat. Thus self-supplied meat will account for

about 17.6% of 11 millions lbs (5,00 million kgs) currently imported.

Projected Input and Output of beef cattle

As for the breed of beef cattle, charolais bull and charbray cow are chosen, and pastured at one head per acre on reclaimable land in the project area. In the pasture, $\frac{1}{4}$ elephant grass for cutting and $\frac{3}{4}$ pangola grass for grazing are planted. The net benefit in this case is as follows:

Annual income

Age	Weight	Dressing percentage	Dressed weight	Unit Price	Price
18 months	800 lbs	50%	400 lbs	TT$0.65 per lbs	TT$260 per head

Annual income: TT$260 per head x 12/18 month ≈ TT$174 per year per acre
(US$215 per year per hectare)

Investment cost of basic facilities

Road construction	TT$105.6 per acre	TT$264 per ha
Water facilities for cattle	15.2	38.0
Electric facilities	11.4	28.5
Grass land establishment	160.0	400.0
Pens & water drinking place	17.3	43.2
Management office	10.5	26.2
Total:	TT$320.0	TT$800.0
		(US$400 per ha)

Annual Payment

Calf	One head per acre	TT$65/acre
Land lease		TT$12/acre
Capital Cost per year	320/50	TT$ 6/acre
Other		TT$ 7/acre
Total		TT$90/acre (US$111 per hectare)

Income ratio

$$\frac{174 - 90}{174} = \frac{84}{174} = 48\%$$

Net Income ratio

$$\frac{174 - 90 - 32}{174} = \frac{52}{174} = 30\%$$

Net income per acre

TT$52/acre = TT$130/ha = US$65/ha

Note: Incomes of the cattle ranchs in U.S.A. in 1967 are as follows:

Area	Number of head	Gross Ranch income	Operating expense	Net Ranch income	Net income ratio	Acre	Nit Income per acre
the Prairies in the north	186.6	18,122	9,014	9,018	50%	4,520	2,015
the northan area of the Rocky mountains	406.0	41,438	22,373	19,065	46%	5,900	3,231
the south-west area	251.9	17,889	11,577	6,312	35%	11,670	0.541
Total	844.5	77,449	42,964	34,485	45%	22,090	1,561

Source: Farm cost and Returns Commarcial Farms by Type, Size and Location, U.S.D.A. Economic Reserch Service, Agriculture Information Bulletin No.230.

Annual benefit

A 5-year period is required for attainment of the planned target of TT$52 per acre (US$65 per hectare). Therefore, annual benefit is estimated at TT$46 per acre (US$57 per hectare) in case of 7% interest rate on 50 years of economic analysis period including discount of time lag. (Refer to Table VI-12)

Annual cost

The construction cost of Ranch is TT$324 per acre (US$400 per hectare) A total of construction cost for 5 years is TT$380 per acre (US$470 per hectare) including interest during construction period. Therefore, annual cost of TT$30.0 per acre (US$37.0 per hectare) obtained by totalling annual amortization cost of initial investment and operation and maintenance cost. (Refer to Table VI-13)

Benefit cost ratio

In case of 3%, 6%, 7% and 10% interest rate, benefit-cost ratio is shown in Table VI-14.

Table VI-14

Benefit Cost Ratio

TT$ per acre (US$ per hectare)

Interest	Annual Benefit	Annual Cost	B/C Ratio
3%	48.8 (60.3)	16.0 (19.7)	3.06
6%	46.7 (57.7)	26.1 (32.2)	1.79
7%	46.0 (56.8)	30.0 (37.1)	1.53
10%	43.8 (54.1)	43.3 (53.5)	1.01

Internal rate of return

Internal rate of return of 10.1% is obtained from the relationship of annual cost and benefit shown in Appendix M (Exhibit M-4).

Repayment capacity

Repayment schedule should be drawn on the basis of net income (TT$52 per acre) because of difference of economic structure between estates and farmers. The amount of amortization is TT$100 per acre (US$123 per hectare on the assumption that initial investment cost of TT$324 per acre (US$400 per hectare) will be financed on 10% interest rate over 17 years including a 5-year grace period. This will make it possible to repay roughly 77%

of the net income and to apply the rest to the capital accumulation.

In other words, the capital accumulation will amount to TT$12 per acre (US$15 per hectare) for initial investment cost of TT$324 per acre (US$400 per hectare), i.e. about 4% per year for its cost.

By reduction of the imports of beef, the saving amount of foreign exchange will amount to TT$1,279,460 (US$639,730) per year, which will contribute much to the national economy. The initial investment cost of TT$324 per acre (US$400 per hectare) which the estates will require, totals TT$2,400,000 (US$1,200,000), the amount of which will be possible to be withdrawn for 2 years. Therefore, the Government should consider to give the estate owner any assistance or to manage the estate by the Government themselves. However, this assistance should be decided after clarifying the future countermeasure for decrease of the beef import because there are the facts of rapidly increasing pork production and the heavy fall of its price. Such uncertain elements as well as insufficient topographical map result in the rough estimation of beef cattle production in this project. Therefore, further clarification for these points should be continuously examined. At the same time, the location suitable for the reclamation, the size of the development area and the idea of development should be identified in more detail after a preparation of topographical map and the fact-finding survey.

Table VI-1 Economic Analysis for Total Project

(Nariva Project in Trinidad and Tobago)

(TT$)

	Irrigation	Livestock	Total
Acreage	9,000 (3,650 ha)	7,400 (3,000 ha)	16,400 (6,650 ha)
Initial Construction cost	16,314,000	2,400,000	18,714,000
- ditto - per ha	4,470	800	2,814
Annual Cost (7%)	1,217,320	158,500	1,375,820
Annual Benefit (7%)	1,295,658	242,777	1,538,435
B/C ratio (7%)	1.06	1.53	1.12
Internal rate of return	7.4 %	10.1 %	7.8 %
Number of Settler & Beef Cattle	640 household	7,400 head	

Note: Refer to Appendix M(M-8, M-9)

Total Yield and Proportion for Imports

	Yield kg/ha or kg/head	Total Cultivated Area or Head	Total Production(kg)	Total Imports (kg)	Proportion for Imports (%)
Crop					
Rice	2,400	5,475 ha	13,140,000	31,660,000	41.5 %
Maize	3,360	912	3,064,320	30,183,000	10.2 %
Soybean	1,900	912	1,732,800	7,560,000	22.9 %
Livestock					
Beef	120	7,400	884,000	5,031,000	17.6 %

Table VI-2 Project Yield and Income (per Hectare)

Crops	Yiels per ha	Price per kg (TT$)	Gross Income (TT$)	Production Cost (TT$)	Net Income (TT$)	Farming Family Income (TT$)
Paddy	4,000 kg	18.0	720.0	408.0	312.0	490.0
Soybean	1,900 kg	13.23	251.4	169.0	82.4	152.4
Maize	3,360 kg	7.72	259.4	189.7	69.7	139.4

Table VI-3 Projected Yields and Income (per Household)

Crops	Season			Yields (ton/ha)	Price (TT¢/kg)	Gross Income (TT$)	Net Income Ratio (%)	Net Income (TT$)	Farming Family Income (TT$)
	Wet	Dry	Total						
	acres		ha						
Paddy	14.00	7.00	21.00(8.51)	33.60	18.00	6,048	43.3	2,619	4,170
Soybean	-	3.50	3.50(1.42)	2.66	13.23	352	32.8	115	216
Maize	-	3.50	3.50(1.42)	4.70	7.72	363	26.9	98	198
Total	14.00	14.00	28.00(11 35)					2,832	4,584
(per hectare)								(506)	(808)

Table VI-4 Annual Benefit (Total Benefit) TT$

(Irrigation)

Interest Rate: 7%

Period of the Analysis: 50 Years

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
(1) Annual Net Income (Full Benefit)	581,900	1,265,000	1,483,845
Straight Line Lag			
(2) Annual Increase			
(1) x $\frac{1}{5}$	116,380	253,000	296,769
(3) Present Worth			
(2) x 11.7469	1,367,104	2,971,966	3,486,116
(4) Amortized for 50 years			
(3) x 0.07246	99,060	215,349	252,604
Complete Lag			
(5) Present Worth at Beginning of 6th year			
(1) x 13.606	7,917,331	17,211,590	20,189,195
(6) Present Worth at Beginning of 1st year			
(5) x 0.7130	5,645,057	12,271,864	14,394,896
(7) Equivalent Annual 50 years			
(6) x 0.07246	409,041	889,219	1,043,054
(8) Equivalent Annual Benefit for Straight Line Lag Period	99,060	215,349	252,604
Total Annual Benefit	508,101	1,104,568	1,295,658
Total Annual Benefit per Hectare	442	442	355

Table VI-6 Annual Cost (Total Ccst) TT$

Interest Rate: 7%
Period of the Analysis : 50 years

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
Estimated Construction Cost and Initial Investment			
(1) Total Construction Cost	5,744,000	10,570,000	13,280,410
(2) Interest During Construction (1) x $\frac{1}{2}$ x 0.07 x 5	1,005,200	1,849,750	2,324,072
(3) Total Initial Invetment (1) + (2)	6,749,200	12,419,750	15,604,482
Annual Cost:			
(4) Operation & Maintenance Cost	38,000	67,000	85,771
(5) Amortization of Investment Cost (3) x 0.07246	489,047	899,935	1,130,701
(6) Price of Replacement (Steel Gate)	40,000	33,000	63,529
(7) Replacement Cost (6) x 0.1842 x 0.07246	534	440	848
Total Cost	527,581	967,375	1,217,320
Total Cost per Hectare	459	387	334

Table VI-8 Investment Schedule

Year	Irrigation and Drainage Work			Farm Settlement		
	Construction Cost			Coop. Facilities	Land Improvement	Mechanization
	Local Genency Gov. Budget	Foreign Exchange Loan	Total			
	TT$	US$	TT$	Local Currency TT$	Local Currency TT$	Foreign Exchange US$
1	566,000	227,000	1,020,000			
2	566,000	227,000	1,020,000			
3	566,000	227,000	1,020,000			
4	566,000	227,000	1,020,000			
5	566,000	227,000	1,020,000	1,300,000	644,000	320,000
Sub-Total	2,830,000	1,135,000	5,100,000	1,300,000	644,000	320,000
6	960,000	437,000	1,834,000			
7	960,000	437,000	1,834,000			
8	960,000	437,000	1,834,000			
9	960,000	437,000	1,834,000			
10	960,000	437,000	1,834,000	2,184,000	1,400,000	635,000
Sub-Total	4,800,000	2,185,000	9,170,000	2,184,000	1,400,000	635,000
Total	7,630,000	3,320,000	14,270,000	3,484,000	2,044,000	955,000

Table VI-9 Payment Capacity by Farmers

		Per Hectare	per Household
(1)	O & M Cost	TT$ 29 = US$ 14.5	TT$164 = US$ 82
(2)	Amortization (for Land Improvement)	TT$ 49 = US$ 25	TT$280 = US$140
(3)	Farming Family Income	TT$ 808 = US$404	TT$4,584= US$2,292
(4)	Saving [(3) x 0.2]	TT$162 = US$81	TT$917 = US$459
(5)	Payment Capacity [(4) x 0.4]	TT$ 65 = US$33	TT$366 = US$183

(5) - (2) - [(1) x 0.5] = 366 - 280 - (164 x 0.5) = TT$4

65 - 49 - (29 x 0.5) = TT$1

Table VI-11 Summary of Payment Schedule

Year	From Co-operation to A.D.B.(L.C.) TT$			From Government to I.F.A. (F.E.) US$		
	Facilities	Land Improvement	Total	Construct-ction	Mechani-zation	Total
			TT$			US$
1	-	-	-	3,405	-	3,405
2	-	-	-	10,215	-	10,215
3	-	-	-	17,025	-	17,025
4	-	-	-	23,835	-	23,835
5	45,500	22,540	68,040	30,645	9,600	40,245
6	91,000	45,080	136,080	82,850	9,600	92,450
7	91,000	45,080	136,080	95,960	9,600	105,560
8	91,000	45,080	136,080	109,070	9,600	118,670
9	91,000	45,080	136,080	122,180	9,600	131,780
10	167,440	94,080	261,520	135,290	51,197	186,487
11	316,550	179,080	495,630	223,171	51,197	274,368
12	316,550	179,080	495,630	223,171	51,197	274,368
13	316,550	179,080	495,630	223,171	51,197	274,368
14	316,550	179,080	495,630	223,171	51,197	274,368
15	316,550	179,080	495,630	223,171	95,939	319,110
16	438,636	257,340	695,976	223,171	95,939	319,110
17	438,636	257,340	695,976	223,171	95,939	319,110
18	438,636	257,340	695,976	223,171	95,939	319,110
19	438,636	257,340	695,976	223,171	95,939	319,110
20	438,636	257,340	695,976	223,171	95,939	319,110
21	438,636	257,340	695,976	223,171	95,939	319,110
22	438,636	257,340	695,976	223,171	63,792	286,963
23	274,966	176,260	451,226	223,171	63,792	286,963
24	274,966	176,260	451,226	223,171	63,792	286,963
25	274,966	176,260	451,226	223,171	63,792	286,963
26	274,966	176,260	451,226	146,876	63,792	210,668
27	274,966	176,260	451,226	146,876	-	146,876
28	-	-	-	146,876	-	146,876
29	-	-	-	146,876	-	146,876
30	-	-	-	146,876	-	146,876
Total	6,604,972	3,875,020	10,479,992	4,712,420	1,294,518	6,006,938

Table VI-12 Annual Benefit (TT$ per Hectare)

(Beef Cattle Farms)

Interest Rate 7%
Period of the Analysis 50 Years

(1)	Annual Net Income (Full Benefit)		130.0
Straight Line Lag			
(2)	Annual Increase	(1) x $\frac{1}{5}$	26.0
(3)	Present Worth	(2) x 11.7469	305.4
(4)	Amortized for 50 years	(3) x 0.07246	22.1
Comlete Lag			
(5)	Present Worth at Beginning of 6th year	(1) x 13.606	1,768.8
(6)	Present Worth at Beginning of 1st year	(5) x 0.7130	1,261.1
(7)	Equivalent Annual 50 years	(6) x 0.07246	91.4
(8)	Equivalent Annual Benefit for Straight Line Lag Period		22.1
	Total Annual Benefit		113.5

Table VI-13 Annual Cost (TT$ per hectare)
(Beef Cattle Farms)

Interest Rate 7%
Period of the Analysis 50 years

Estimated Construction Cost and Initial Investment:		
(1)	Total Construction Cost	800.0
(2)	Interst during Construction Period (1) x $\frac{1}{2}$ x 0.07 x 5	140.0
(3)	Total Initial Investment (1) + (2)	940.0
Annual Cost:		
(4)	Operation and Maintenance Cost	6.0
(5)	Amortization of Investment Cost (3) x 0.07246	68.1
(6)	Replacement Cost	-
	Total Cost (per Hectare)	74.1

Chapter VII

PROJECT ORGANIZATION

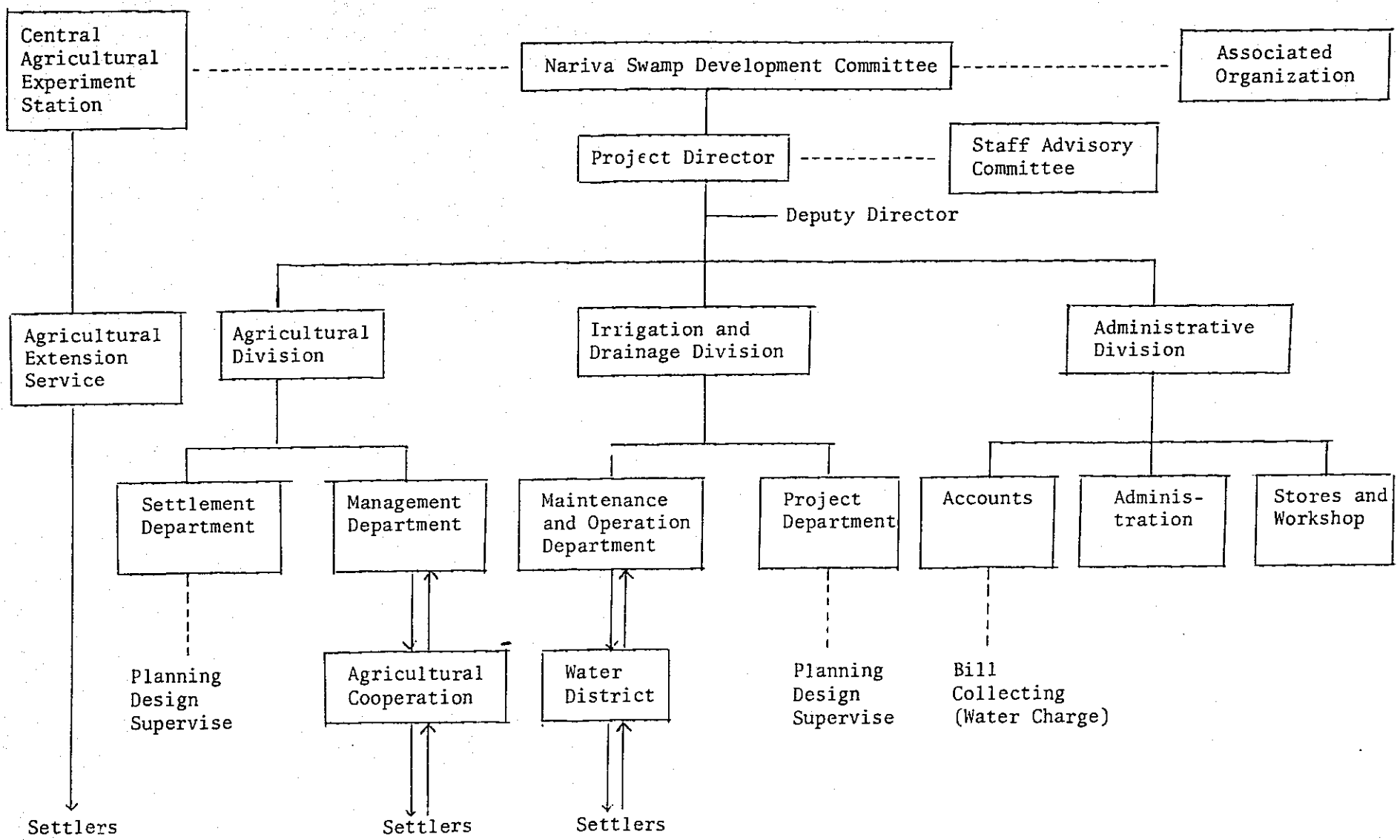
Organization authority

The project consists of the irrigation development for paddy, soybean and maize on the swamp area and the reclamation development for beef cattle raising on the hilly lands on the east part of this country.

Administrative authorities such as the Ministry of Construction, the Ministry of Agriculture-Forestry, the Ministry of Economic Planning, the Ministry of Finance and so on will be involved in the construction works and the operation of the project. It is not efficient that each authority will independently invest in and promote the project. A director representing the Government should be responsible for implementation of the project. (Refer to Table VII-1) This director should report the progress of the project to the Nariva Swamp project Committee, which is composed of the following members: deputy minister of the Ministry of Economic Planning (chairman), deputy minister of the Ministery of Public Works, deputy minister of the Ministery of Agriculture-Forestry, general manager of Agricultural Development Bank, a representative of The University of West Indies, 3 senior engineers, 2 senior economists (economist of the Ministry of Economic Planning and agricultural economist of the Ministry of Agriculture-Forestry) and project director. The committee functioning as a comprehensive advisory body to the Government should also review the progress of project implementation and extend their cooperation to each authority in the course of the implementation, for instance, to the Industrial Development Cooperation for arrangement of processing factories of agricultural products and to the National Housing Cooperation for construction of farmers' houses in the project area.

The abovementioned director should be authorized by the international financing agency. The project director should be assisted by a staff advisory committee, which is composed of engineers, accountants, agricultural records analysists and agricultural credit's experts of Agricultural Development Bank.

Table VII-1 Project Organization



Project Construction

The foreign aid fund for the project is to be financed by international financing agencies, by which the construction designs, specifications and the standards of materials should be passed prior to the commencement of construction works.

The civil engineering works in each stage of the project plan will be carried out by a certain world-renowned certificated contractor. If the construction works is carried out by a foreign contractor, a tie-up will be made between foreign and local contractor. It is no doubt that through the tie-up the local contractor will be of benefit to the level-up of civil engineering.

Large-sized equipments for the project should be inspected at the manufacturing company, transported with care, and operated on trial after being installed at the site, by experts.

The project organization should include personnel to supervise the contractor and suppliers at the project site during a period of the construction works as shown in Table VII-2. Prior to the start of the project construction works, the Government will employ consultants from abroad. The Trinidad and Tobago's engineers will join as counterparts to cooperate with the consultants or be adopted as technical staff by the consultants for getting technical training of specifications, designs and inspections of civil engineering works. After completion of the project construction works, these staff will be most capable members of operation and maintenance department.

Table VII-2

Construction Inspection Personnel

Professional Personnel	No. Required
Project Engineer	1
Assistant Engineers	2
Construction Engineers	5
Lab. Assistants	5
Soil Engineer	1
Lab. Assistants	2
Mechanical Engineer	1
Draftmen	2
Inspectors	7
Surveyors	2
	28
Non-Professional Personnel	
Truck Drivers	2
Janitor	1
Clerks	2
Rodmen and Chairmen	4
Laborers	3
Typist	1
Telephone Operators	2
	15

Project development

On the way to the project development, there should be established two departments in the irrigation and drainage division and agricultural division, respectively.

The project department carries out to plan, design, and supervise the construction works. The settlement department draws up and carries out a plan of land allocation, housing construction, water and power

supply. After completion of the construction works by each stage, the project department transfers the operation and maintenance of the project to the maintenance and operation department. The Crown land is allocated and lent to the settlers for the farm land in the project area. Group farming is operated with an adoption of a cooperative system by the settlers consisting of 30 households each, in view of a large scale of agriculture by mechanization (Refer to L-13 production cost).

The project department and settlement department work together with each other essentially in the initial stage of the project, but reduce gradually their scales of organization toward the end of capital investment. The maintenance and operation department and the agricultural management department shall enlarge their scales at the time when the settlers start the production in the project area, and the both departments shall exist forever as important organizations. (The agricultural management department shall be finally transferred to the cooperative).

Technical services after completion of the construction

Agricultural extension service office and pilot farm station should be established by the budget of the Government at an eariest time of the construction works and prior to the settlement in the project area. The projected yields will be realized by the settler's joint use of large agricultural machinery in 5 years after completion of the construction works. For attainment of the projected yields, fertilizers, chemicals, and other materials together with machinery parts and repair shop should be provided in addition to the technical services stated above.

An emphasis in the agricultural management department should be placed on technical training of big-sized agricultural machinery and procurement of the above mentioned materials and others. The Development Authority will otherwise face difficulty in collection of amortization and water charges or land taxes. For that, survey of canals, reasonable distribution of water, and planned distribution of water to the terminal

areas made by the maintenance and operation department, should be confirmed by both of the farmers and the Development Authority. If claims were made for the distribution of water by the farmers, the Development Authority will face more difficult collection of amortization and water charges. It is of utmost importance that an emphasis should be placed on a close relationships among (1) maintenance and repair of canals, distribution of water, (2) procurement of agricultural materials and (3) extension service of agricultural techniques. It is of particular importance for the Development Authority to have a close relationship with the extension services.

The agricultural cooperative, organized by the settlers, should be operated, as a rule, by the representatives of the settlers. In the initial stage of the settlement, the settlers are so busy establishing their own farming system that there will not be enough time to manage the agricultural cooperative. Therefore, the Agricultural management department of the Development Authority should assist the settlers in the operation of the cooperative (at least 5 years) before they can properly engage in it as well as in farming operation.

The agricultural cooperative organized by the farmers should place an emphasis on management of depot as well as marketing of their member's agricultural products. The Agricultural management department of the Authority should be responsible for the purchasing activity for a rather long time in view of difficult aspects such as the operation of capital, the disposal of stock, the inventory and so forth. The Authority should continue their services to the Agricultural cooperative until the settlers of Stage II attain the projected yields (about 10 years from the start of the settlement of stage I). In review of economic situation at that time, an overall activity of the Agricultural management department should be transferred to the Agricultural Cooperative sttlers in parallel with a reduction or abolition of the agricultural management department of the Authority. The maintenance and operation department should be in existence to an end. The number of the personnel is estimated as shown in Table VII-3.

Table VII-3

Operations List of Personnel

	No. of Personnel
Superintendent	1
Chief water master	1
Ditch Riders	10
Clerks	4
Telephone Operator	1
Foremen	2
Equipment Operators	4
Mechanics Laborers	2
	15
	40

As already mentioned, the estates should carry out reclamation works for beef cattle raising, but the estates should get an approval of the committee on basic plans concerning construction works (roads and wind belt), land utilization and so forth for enabling the estates to do the efficient development works. It may be regulated if necessary that the reclamation works be executed by the estates after being entrusted by the committee.

In review of the existing villages as well as the irrigation and drainage area and the livestock area, schools and hospitals should be established by the budget of the Government in time for operation in line with a start of the settlement.

Water rights

An article of water right for exclusive use of water developed by the project should include in the constitutions of the project organization. The Government should provide for a special law of water right if not mentioned in the national law of Trinidad and Tobago.

EXHIBITS

Itinerary of field survey

March 10, 1968	the first group Departed from Tokyo and arrived in Los Angeles
March 11, 1968	Departed from Los Angeles and arrived in Caracas
March 12, 1968	Visited the Japanese Embassy at Venezuela Discussed field survey site with the Japanese envoy to Venezuela
March 13, 1968	Departed from Caracas and arrived in Port of Spain accompanied by Mr. Ito, secretary of the Japanese Embassy at Venezuela
	the second group Departed from Tokyo and arrived in Los Angeles
March 14, 1968	the first group Visited the Ministry of Construction and interviewed with Mr. Victor Campbell, Minister for Construction Visited the Ministry of Economic Planning and interviewed with Mr. Eugenio Moore, Vice-Minister for Construction
	Held a meeting with officials concerned of the Trinidad and Tobago Government at the Ministry of Economic Planning and discussed the itinerary of field survey and counterpart collaboration by the Government.
	Visited the Ministry of Agriculture-Forestry and held a meeting with Mr. L. M. Robinson, Minister for Agriculture-Forestry and Mr. Frank Barsotti, Vice-Minister for Agriculture-Forestry
	the second group Departed from Los Angeles and arrived in Port of Spain
March 15, 1968	Interviewed with a pressman of 'Sunday Guardian' Attended the dinner party given by Mr. P. J. Williams
	Discussed with officials of the authorities concerned of Trinidad and Tobago Government

LIST OF EXHIBIT

Number	Title
I-1	General Plan
I-2	Plan of Watershed for Project Area & Location of Rainfall Stations
I-3	Graphic Precipitation & Temperature
III-1	Survey of Nariva Area
III-2	Surface Area of a Reservoir and Volume of Water Storage

March 16, 1968	Made an observation trip to Nariva Swamp area (Brigand Hill, Nariva River Mouth, Plum Mitan Road, Rio Claro Road and so on)
March 17, 1968	Mr. Ito, secretary of the Japanese Embassy at Venezuela returned.
	Some members of the first group made an observation trip to Manzanilla after a reconnaissance survey of northern Nariva Swamp area
	Visited the Ministry of Economic Planning and discussed agricultural economic data with Mr. D. Workman
	Arranged materials and machinery for field survey
March 18, 1968	Made a reconnaissance survey of Plum Mitan and Sand Hill
	Exchanged views with Mr. C. G. Atala, Carbean Regional Office at Banco Inter-Americano de Desarrollo
	Exchanged views with Mr. Ross, chief of the World Bank Economic Mission
	Discussed and aerial survey at the Ministry of Economic Planning
	Visited Nariva Cocal Ltd. and discussed the means of contacts between Port of Spain and Manzanilla with Mr. M. Anderson
March 19, 1968	Made an aerial survey
	Made a reconnaissance survey of Petite Poole Cut, Jagroma River, Canque River, Hart Road and L'Ebranche River Mouth
	Exchanged views with Mr. Selvanayagan and Mr. Conaghy, professors of the University of West Indies
March 20, 1968	Made an aerial survey
	Made a trip to Country Office (Sangrande) for observation of Extension Work

March 21, 1968	Made a reconnaissance survey of Biche Ortoire Road, Lassalle Road, Matin Saza Road and Charuma River
	Visited Sangre Grande County Office and discussed current situation on swamp development with Mr. R. Joseph
	Received materials and equipments for field survey
	Discussed detailed itinerary of field survey
March 22, 1968	Made a survey of the erosion of the coasts at Mayaro, Manzanilla and Ortoire River Mouth
	Visited Banana Plantation to obtain information on the agricultural conditions of the Plantation and its surroundings
March 23, 1968	Made a survey of agricultural conditions of Banana Plantation and its surroundings
	Discussed a reconnaissance survey
March 24, 1968	Transported machinery borrowed from the Trinidad and Tobago Government to survey site
	Made a reconnaissance survey in the area between Plum Mitan and Jagrom
	Made a levelling of the area between Bench Mark (No.822) and Plum Mitan Gate
	Made a survey of water quality and water depth around railway bridge across Nariva River
March 25, 1968	Made a reconnaissance survey of L'Ebranche River
	Made an observation trip to the Government-operated Tobacco Factory
March 26, 1968	Made a reconnaissance survey and soil sampling of Black Water River and Bois Neuf
	Engineering group camped at Black Water River
March 27, 1968	Made a reconnaissance survey of Bois Neuf and Navet River

March 27, 1968	Engineering group camped along Bois Neuf and Navet River
	Economic group visited the Ministry of Economic Planning and discussed agricultural economic data with Mr. D. Workman
March 28, 1968	Coordinated engineering team's findings at Bois Neuf
	Made a study of data of the 3rd 5-Year Program
March 29, 1968	Made an observation trip to Navet Dam site
	Made a levelling of Pierre Road and placed water gauge at the Manzanilla coast
	Made an analysis and a calculation of excessive probability of wave
	Made a soil sampling
	Made a study of data related to Crown Land developed by the finance of the World Bank
March 30, 1968	Made a soil sampling at Plum Mitan and survey of transverse structures established along Plum Mitan Road
	Made a levelling of Pierre Road
March 31, 1968	Visited Drainage Department of the Ministry of Construction
	Exchanged views on data related to hydrology with Mr. C. Taylor (Chief of Drainage Department) and his staff.
	Made a levelling of Ward Road and New Land Estate
	Made a topographical survey of the Nariva River Mouth
	Made a soil sampling
April 1, 1968	Visited the University of West Indies
	Discussed soil analysis
	Collected data related to agricultural economy

April 1, 1968	Made a levelling of Biche Ortoire Road and Marcano Trace
	Made a topographical surveying of L'Ebranche River
April 2, 1968	Visited the University of West Indies
	Discussed and made a study of soil analysis
	Visited Drainage Department of the Ministry of Construction
	Exchanged views on data related to hydrology of Navet Dam and Navet River with Mr. T. Smith, Mr. E. Wyke and Mr. J. Hope, Canadian consultants, and Mr. J. Price, Water & Sewerage Authority
	Made a levelling of Martin Trace and Lassalle Road
	Made a topographical surveying of L'Ebranche River
April 3, 1968	Made a observation trip to Nariva area (Brigand Hill, L'Ebranche River Mouth, Caltoo Trace, Biche Ortoire Road and so on) with Mr. C. Taylor and Mr. C. Narain, Drainage Department of the Ministry of Construction and Mr. D. Workman, the Ministry of Economic Planning
	Made a levelling of southern Cunapo Road
	Made a topographical surveying of Nariva River Mouth
	Made a soil sampling
April 4, 1968	Made a topographical surveying and levelling of L'Ebranche River Mouth
	Made a levelling of Hart Road
	Made a soil sampling
April 5, 1968	Made a survey of water requirement in depth at Plum Mitan
	Made a levelling and observation of water level and discharge at Nariva River Mouth
	Made a soil sampling

April 6, 1968	Made a surveying of water requirement in depth at Plum Mitan
	Made a topographical survey and sounding of the Cocos coast
April 7, 1968	Made a cross-sectional levelling, coast sand sampling, sand test, levelling and water requirement in depth at Nariva River Mouth and Mita
April 8, 1968	Visited the Ministry of Agriculture-Forestry
	Exchanged views on agricultural economy and relative data
	Visited Drainage Department of the Ministry of Construction
	Discussed and made a study of hydrological data including river discharge and rainfall of Navet River with Mr. C. Taylor (Chief of Drainage Department) and other officials
	Visited the University of West Indies
	Made a request for soil analysis and exchanged views
	Made a levelling
April 9, 1968	Mr. M. Kajiki, Director of Construction, Agricultural Land Bureau, the Ministry of Agriculture-Forestry, Government of Japan and Mr. Suzuki, Director of Sanyu Consultants International, Inc. Japan who arrived in Port of Spain made an observation trip to Nariva area (after attendance at a general meeting of I.C.I.D. held in Mexico)
	Made a survey of water requirement in depth
	Attended a cocktail party given by the leader of survey team
	Interview with Mr. F. Barsotti, Vice-minister for the Agriculture-Forestry and other Government officials concerned
April 10, 1968	Visited the Ministry of Agriculture-Forestry

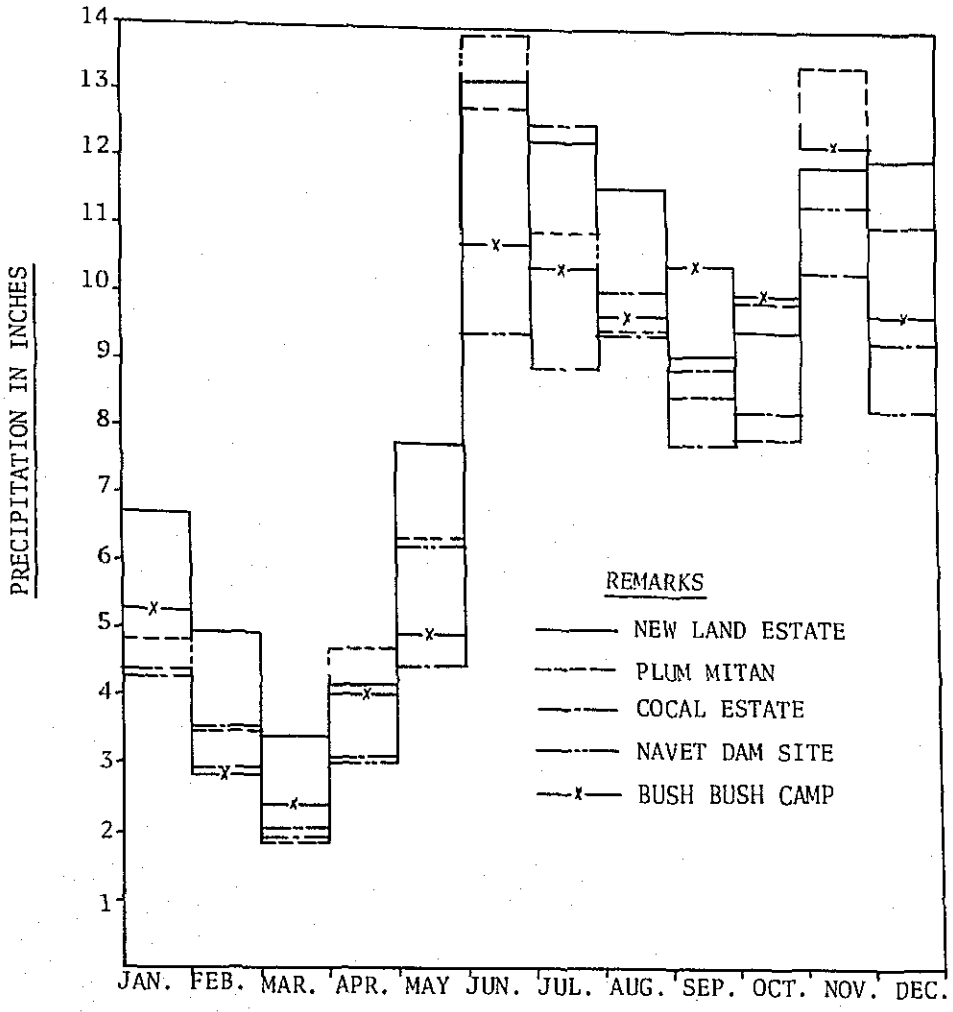
April 10, 1968	Exchanged views with officials of the Ministry and collected data related to agricultural economy
	Made a survey of water quality and water requirement in depth of Nariva River with cross-sectional levelling
April 11, 1968	Visited the Ministry of Economic Planning
	Exchanged views with officials of the Ministry
	Collected relevant data
	Made a cross-sectional levelling and a survey of water requirement in depth of L'Ebranche River
	Marked 5 boring test places
April 12, 1968	Visited the University of West Indies
	Exchanged views with Dr. Edwards, Chief Professor of faculty of agricultural economics
	Collected Data
	Made a levelling of 5 boring test places
	Made a survey of water requirement in depth
April 13, 1968	Discussed by the itinerary of remaining survey work and the preparation of the interim report
	Arranged data
April 14, 1968	Visited the University of West Indies
	Collected and reviewed data
	Coordinated opinions for the interim report
April 15, 1968	Visited Drainage Department of the Ministry of Construction
	Made a study of hydrological data
	Visited the Ministry of Economic Planning
	Visited I.D.B. and exchanged views

April 15, 1968	Prepared the draft of the interim report
April 16, 1968	Visited the Central Marketing Agency and Interviewed with Mr. Skinner, manager
	Received an explanation of Dr. T. Carr during the visit to the Texaco Food Crop Demonstration Farm
	Received an explanation of Dr. V. C. Henry during the visit to the Central Experimental Station
	Received an explanation of La Compensation Food Project by Mr. R. Greaves and Dairy & Pig Project by Mr. A. Ramcharan
	Received an explanation of construction machinery and their prices from construction establishments in Trinidad and Tobago
	Made a study of statistical data at Drainage Department of the Ministry of Concstruction
April 17, 1968	Visited the Ministry of Economic Planning
	Made a reconnaissance survey of the northern coast of Nariva
April 18, 1968	Departed from Port of Spain and arrived in Caracas
	Leader of survey team and its members visited the Japanese Embassy at Venezuela for discussion of the interim report
	Explained the progress of the survey to Japanese ambassador at the Embassy
	Prepared the interim report
	Arranged the survey equipment and materials in order
April 19, 1968	Moved to Port of Spain from Manzanilla Base Camp
	Leader of survey team and its members returned from Caracas
	Prepared the interim report
April 20, 1968	Made an observation trip to Tobago and an overnight stay at Tobago

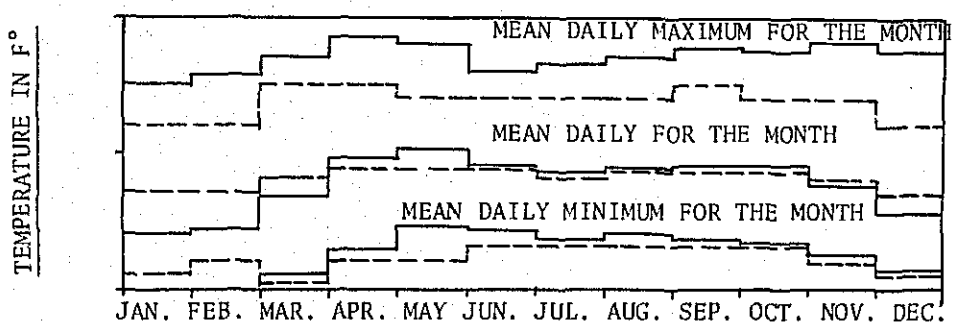
April 21, 1968	Prepared the interim report
April 22, 1968	Prepared the interim report
April 23, 1968	Prepared the interim report
April 24, 1968	Offered greetings to Mr. V. L. Campbell, the Minister for Construction
	Prepared the interim report
April 25, 1968	Received a visit of Mr. Ito, Secreatry of the Japanese Embassy at Venezuela to Trinidad
	Submitted the interim report to Mr. D. Workman and held a meeting for discussion with officials of the Government authorities concerned at the Office of the Ministry of Economic Planning
	Discussed the procedure of preparing the final report after return to Japan
April 26, 1968	the first group
	Departed from Port of Spain and arrived in New York
	Mr. Ito, Secreatry of the Japanese Embassy at Venezuela returned
	the second group
	Arranged survey equipments and materials in order
April 27, 1968	the first group
	Departed from New York and arrived in Washington, D.C.
April 28, 1968	the first group
	Visited the office of the World Bank and exchanged views and explained the field survey performed collected data
	Made an observation trip to Pitch Lake

April 28, 1968	the second group
	Finished the procedures for sending back collected data, materials and machinery for the survey
April 29, 1968	the first group
	Visited the Inter-American Development Bank
	Exchanged views and explained the field survey performed
	the second group
	Visited and offered greetings to the Drainage Department of the Ministry of Construction, the Ministry of Economic Planning and the University of West Indies
	Prepared for return to Japan
April 30, 1968	the first group
	Departed from Washington, D.C. and arrived in Los Angeles
	the second group
	Departed from Port of Spain and arrived in Los Angeles
May 1, 1968	Joining of two groups
	Departed from Los Angeles
May 2, 1968	Arrived in Tokyo

Exhibit I-3



MEAN MONTHLY PRECIPITATION



MEAN MONTHLY TEMPERATURE

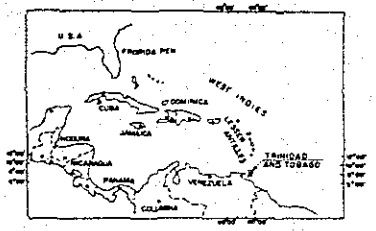
REMARKS

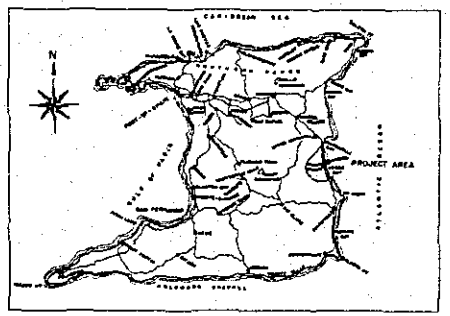
——— PIARCO AIRPORT (FROM 1951 TO 1964)

----- NAVET DAM SITE (IN 1968)

GRAPHIC PRECIPITATION & TEMPERATURE

Exhibit I-1





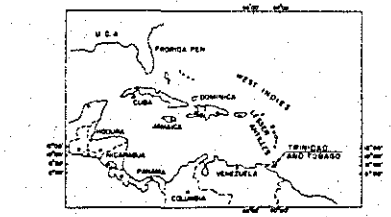
LOCATION MAP

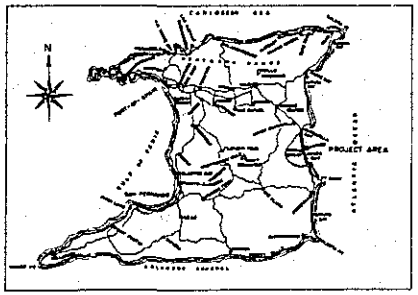
LEGEND

- MAIN IRRIGATION CANAL
- MAIN DRAINAGE CANAL
- EARTH FILL DAM
- MAIN ROAD
- CONTOUR LINE IN FEET
- EXISTING ROAD
- BOUNDARY OF WATERSHED AREA
- EXISTING DRAINAGE CANAL
- LOCATION OF SETTLEMENT

SCALE

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
THE NARVA SWAMP AGRICULTURAL DEVELOPMENT PROJECT	
GENERAL PLAN	
SANYU CONSULTANTS INTERNATIONAL, INC.	
SUBMITTED	DATE
APPROVED	DRAWING NO.





LOCATION MAP

LEGEND

- MAIN IRRIGATION CANAL
- MAIN DRAINAGE CANAL
- EARTH FILL DAM
- MAIN ROAD
- CONTOUR LINE IN FEET
- EXISTING ROAD
- BOUNDARY OF WATERSHED AREA
- EXISTING DRAINAGE CANAL
- LOCATION OF SETTLEMENT

SCALE

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN	
THE NARIVA SWAMP AGRICULTURAL DEVELOPMENT PROJECT	
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