PREFACE

The Trinidad and Tobago Government, which had the intention of developing the Nariva swamp in Trinidad into a farming land contributing to the increase in the food production of the country, reguested the Japan economic mission to obtain the co-operation of Japanese Government in this project in Jan. 1965, when the mission made a visit of the country.

In compliance with this request of the Trinidad and Tobago Government, the Japanese Government has decided to make a pre-investment fundamental survey of the Nariva area for the development, and entrusted the Overseas Technical Co-operation Agency with this task. In Sept. 1966, the agency dispatched a survey team of 3 experts in agricultural development headed by Mr. Kensaku Takeda.

On the job site, the survey team investigated the condition of Nariva area, collected and investigated the necessary data, etc. for about a month, and returned to Japan in mid-October. In relation to the development of Nariva area, therefore, we have since then examined the method of land utilization, drainage, irrigation, and working programs, calculated the cost of construction, and hereby submitted the report to you.

If this survey report contributes to the new orientation of the development in the Nariva area and the materialization of proper development project, and serves the promotion of friendly relations and economic interchange between Japan and Trinidad and Tobago we Overseas Technical Co-operation Agency could be very happy.

In conclusion, I have to express our sincere gratitude, in behalf of the Agency, for the facility and assistance extended to the mission by the authorities of the Trinidad and Tobago Government, particulary by the Agriculture and Forestry Department.

S. Shibusawa

Shin-ichi, Shibusawa,
Director General of the Overseas
Technical Co-operation Agency

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CHAPTER I INTRODUCTION

Chapter I Introduction

1. Development and the objective of the survey

In January, 1965 when the economic mission dispatched by the Japanese Government paid a visit to Trinidad and Tobago, their Government requested the mission to obtain the co-operation of Japanese Government in developing the Nariva swamp area in the central and east regions of Trinidad Island.

In compliance with the above request, the Japanese Government immediately dispatched a survey team consisting of 3 experts in agricultural development in Sept. 1966 to make a preliminary study of the feasibility of development in the Nariva swamp area.

Trinidad and Tobago Government has the desire of developing the Naria swamp into farm land, which would greatly contribute to the increase in the agricultural production of this country, especially in the food production.

The duty of this survey team was to investigate various data and informations available at present, and make preliminary observations on the feasibility of agricultural development in the Nariva swamp area from a technical and economic viewpoint on the basis of the survey on the site.

2. Organization of the survey team

Head of the team:

Kensaku, Takeda, Acting Chief of the Design Section, Construction Division, Agricultural Land Bureau, Ministry of Agriculture and Forestry (civilengineer in charge of irrigation and drainage)

Vice-head of the team:

Izumi, Miyamoto, Chief of the Resources Section, Planning Division, Kanto Regional Office of the Ministry of Agriculture and Forestry (agronomist)

Member of the team:

Yuzo, Okajo, Technical Official of the Design Section, Construction Division,

Agricultural Land Bureau, Ministry of Agriculture and Forestry

(civil engineer in charge of irrigation and drainage)

3. Method of the survey

In studying the feasibility of the development of the Nariva area into an arable land, we have employed the following methods in the recent survey:

(a) Collection of various data and informations

Data we have recently collected are as shown in the separate attached Table (List of the collected data)

(b) Aerial reconnaissance of the Nariva area by means of light aeroplane

The job site was said to be not accessible. Not only that, the overland access, especially to the inside seemed very difficult, because it was the rainy season. On the other hand, it was necessary for the team to grasp the whole aspect of a vast area for a short period. Under such conditions, aerial reconnaissance by light aeroplane was very effective. In this connection, we were very happy, as we could use a rescue Sesna plane of the Coast Guard through good offices of the Government.

(c) Survey of the site

Approach to the in side of the area was not so difficult as expected. Except in the Plum-Mitan area, however, the advance by car is impossible, because there is no road. This is also the case with the dry season. We have subsequently approached the major points in the area by boat or on foot to observe the topographical condition of the site, condition of water, soil, etc. and collect some soil samples, For the reason of rainy season, however, we could approach only extremely limited points.

(d) Hearing the opinions of related well-informed persons

Hearing was given to collect the data mentioned in the above item a), we have

called on the leading officials of various Government organs, professors and employees of the university of West Indies, and the leaders of private enterprises.

4. Itinerary of the survey team

10 Sept. 1966 (Sat.)	Left Caracus – arrived at Port of Spain (Trinidad and Tobago)
11 Sept. 1966 (Sun.) 12 Sept. 1966 (Mon.)	1. Inspected the Nariva swamp area, and called at the Ministry of Agriculture and Forestry to have an interview with the Minister. 2. Met the officials of the related organs of the Trinidad-Tobago Government at the Prime Minister's Office to make arrangements for the survey program. 3. Called on Dr. Cyril Brown, University of West Indies to hear the explanation of the land utilization in the Nariva area. 4. Called at the Ministry of Works to make arrangements with Mr. Taylor and Mr. Narine for the data on the drainage.
13 Sept. 1966 (Tues.)	1. Called at the Central Statistics office to collect the collect the data upon the statistics of agriculture. 2. Met Mr. Bharath and other staff at the Central Research Station to make inquiries about the agricultural products in Trinidad and Tobago.
14 Sept. 1966 (Weds.)	1. Called at the Ministry of Agriculture and Forestry to inquire Mr. Ferrer of the agricultural products market. 2. Called at the Economic Planning Division to make arrangements with Mr. Rampersad and Mr. Moore for the schedule of the survey.

15 Sept. 1966 (Thurs.)	1. Called at the Land and Survey Department to make arrangements with Mr. Gooden Herrel for the maps of Nariva area.
	2. Called at the Water and Sewerage Authority to inquire about the Navet dam.
16 Sept. 1966 (Fri.)	1. Called at the Ministry of Agriculture and Forestry to inquire the crops of Mr. Hamilton.
	2. Called at the Trinidad and Tobago Agricultural Society to inquire about the future development in the Nariva area.
	3. Made arrangements for the aerial reconnaissance program at the Economic Planning Division.
	4. Called at the Ministry of Works to make arrangements with Mr. Taylor for the bench mark (B.M.) and the aerial reconnaissance.
	5. Called at the Government Farm, to inquire the livestock raising of Dr. Gonzalez.
17 Sept. 1966 (Sat.)	Visit the Jayland Fair held in San Fernando.
18 Sept. 1966 (Sun.)	Holiday
19 Sept. 1966 (Mon.)	1. Aerial reconnaissance.
	2. Called again at the Central Statistics Office for the statistical data.
20 Sept. 1966 (Tues.)	Called at the University of West Indies (Agricultural and Technical Engineering Faculties) to inquire the expert professors and researchers of the future trend of the study of agricultural products, and to observe the soil and civil engineering research laboratories.
21 Sept. 1966 (Wed.)	1. Aerial reconnaissance.

	2. Called on Dr. Brown at University of West Indies to make arrangements for the data upon the land utilization in the Navari area.
22 Sept. 1966 (Thurs.)	Left Port of Spain for Mayaro, where the team made arrangements with the guide for the concrete plan of survey on the spot.
23 Sept. 1966 (Fri.)	Went up the Brigand Hill from Mayaro, and commanded a view of the whole area. Inspected the rice scheme in the Plum-Mitan district Surveyed the Sand Hill on foot (for the soil sampling and others)
24 Sept. 1966 (Sat.)	Surveyed the Eastern Nariva area (entered from the Cascadeux road, crossed the area on foot, and went out the Manzanila coast along the Kernahan road)
25 Sept. 1966 (Sun.)	Arrived in the Plum-Mitan rice-producing district through Rio Claro from Mayaro, and surveyed the environment along the drainage canals on board the boat. Surveyed the section from Petite Poolo Cut from the Sand Hill Cut (Soil sampling and others)
26 Sept. 1966 (Mon.)	Passed by Cocal from Mayaro, entered the Nariva swamp area by a boat of the Trinidad Regional Laboratory, and surveyed the Bush-bush district (Soil sampling and others)
27 Sept. 1966 (Tues.)	Went through Plum-Mitan from Mayaro, and entered the Jagroma point, where the investigation was given (Soil sampling and others)
28 Sept. 1966 (Wed.)	Advanced along the drainage canal of the Caltoo No.2 district from Mayaro by boat, went through the Jagroma Cut from Sand Hill Cut, observed the

	excavation of the canal by means of dragline, and surveyed the Biche farmland from the Canque River.
29 Sept. 1966 (Thurs.)	Went through the farm of Mr. Bovell, from Mayaro, and set up a water-gauge at the mouth of Nariva River. Went to the Plum-Mitan district to investigate the water requirement.
30 Sept. 1966 (Fri.)	Went from Mayaro to the fiber woorkshop of Mr. Bovell in the morning, near which the water-gauge was set up. Visit the Navet Dam of the upper stream of Navet River in the afternoon.
1 Oct. 1966 (Sat.)	Went from Mayaro to the Nariva and Petit Tuero Rivers via the Naparima-Mayaro Road to inspect the rivers (Soil sampling and other works)
2 Oct. 1966 (Sun.)	Went from Mayaro to Brigand Hill to observe the topographical condition of the whole area again, and then made arrangements at the hotel.
3 Oct. 1966 (Mon.)	Went from Mayaro to the mouth of the Nariva River in the morning, where the team got on board a boat of Regiona Virus Laboratory, sailed up the Nariva River to 80 chains of the upper stream via Dabloon for the survey and then returned to the hotel. Moved to Port of Spain in the afternoon.
4 Oct. 1966 (Tues.)	1. Called at the harbor master's office of Port of Spain, where the team inquired the tidal change of Captain Victor Walker. 2. Met the members of the Feed Millers Association to hear their explanation of the demand and supply of feed. 3. Called on the leaders of the Trinidad and Tobago

	Electricity Commission to hear the explanation of the power supply of this country.
5 Oct. 1966 (Weds.)	
9 Oct. 1966 (Sun.)	Prepared the interim report.
10 Oct. 1966 (Mon.)	1. Met the officials of the Government organs in charge of the affair, submitted the interim report, and explained it (at the Economic Planning Division)
	2. Called on the Minister of Agriculture and Forestry to submit the interim report.
	3. Called on Dr. Eric, Williams, Prime Minister of Trinidad and Tobago Government at his official residence to submit the interim report.
11 Oct. 1966 (Tues.)	Left Port of Spain and arrived in Caracus.
12 Oct. 1966 (Weds.)	Called at the Japanese Embassy to make report on the survey.
13 Oct. 1966 (Thurs.)	Left Caracus for Tokyo.

5. History of the development of Nariva area

5.1 Agricultural potential in this area has long been recognized by the persons concerned. This is also conceivable from the fact that the Plum-Mitan rice scheme was put into practice about ten years ago. This Plum-Mitan rice scheme has covered the northern part of Nariva swamp, approx, 1, 200 acres, where the rice growing is to be given. In this area, (canals) are completed for irrigation and drainage. At present, however, the terminal portions of the drainage canal are silted up by sediment so that they cannot fully display its function. Therefore, the rice is grown in part of the area, no more then 500 acres only in rainy season. In some part of this district, meanwhile, watermelon, tomato, etc. seem to be grown in dry season.

5.2 Except in the Plum-Mitan district, no cultivation is given. In some district (easily accessible from the existing road), some farmers seem to grow the rice in rainy season, and raise the watermelon, tomato, etc. in dry season without permission.

5.3 In the most part of Nariva area, only some fishing (mainly the fish called the "Cascadura") and hunting are conducted.

5.4 Investigation made by the FAO

Investigation for the development of Nariva area based upon the Expanded Technical Assistance Program of the FAO (Food and Agriculture Organizations of the United Nations) was made during the period from 1954 to 1956. The objective of the FAO investigation was to examine various existing data upon the feasibility of the reclamation of the Nariva and Caroni swamp areas to promote the increase in rice production in this country, and to give the government of the country advice for the measure to make a major rice producing center of these two areas. The areas to be investigated were firstly the Nariva and Caroni swamps, and later three areas: Oropouch lagoon, Fishing Pond and Larentille swamp were added.

The organ, which practically made this investigation, is Firm of Engineering Consultants, Holland, entrusted by the FAO.

This investigation report was made public by the FAO in 1957 under the title of "Report to the Government of Trinidad and Tobago on the Reclamation of the Caroni, Oropouch and Nariva Areas".

In relation to the development of Nariva area, the above report has pointed out the followings:

(a) In developing the Nariva area, the highland of the west side should be firstly developed.

(b) If the overall development of this area is not put into practice, it is possible that the polder system would be developed in a flat ground, 4,600 acres on the higher land. As this ground is in the middle of the swamp area, however, it is not easily accessible from the existing village. This is a large defect.

(c) In order to work out a concrete program for the development of this area, more detailed soil investigation is required.

(d) Improvement of the drainage condition is the most important factor in developing this area. This development work should be, therefore, conducted in combination with the improvement projects for many rivers flowing into this area.
In the report, meanwhile, the following is pointed out: Too positive attitude should not be assumed toward the project for developing the swamp into a farm land for the following reasons; Soil condition of the swamp area of this Island does not seem specially good, and the cost for the drainage works is also considerably high.

6. Summary

As the period of our recent survey was short, and sufficient data were not made available to us, further more surveys are required for working out a detailed final project for developing the Nariva area. In order to find the feasibility of the development of the Nariva area, however, the team was attempted the investigation as far as possible on many assumptions according to various data made available to us, and the records of the on-the-spot survey. Its details can be summarized as follows:

6.1 Present condition

6.1.1 Location and the acreage

Nariva area is located in the middle and eastern regions of Trinidad Island, and its east side fronts the Atlantic Ocean. From north to southwest, this area is surrounded by the eastern edge of the central range, and it forms a triangle with its base in the south, and its vertex in the north.

This area is surrounded by the roads permitting the motorcar traffic: Lower Manzanilla road, Plum-Mitan road and Cunapo southern road in the north and west sides, and the Rio Claro-Mayaro road in the south. The east side of this swamp, i.e, the Atlantic side

has a long and narrow beach bank where the coconut plantations have since several hundred years ago been developed. Through the above beach bank, the so-called Cocal road runs. This area is approx. 45 miles off Port of Spain, capital of this country. It takes about one hour and a half by motorcar.

The acreage of the Nariva area is said to be approx, 60, 000 acres. As it includes the hill slope approx. 30 feets above the flat level of the swamp, the acerage of the portion excluding the steep sloped portion, which is to be developed separately, would be approx. 40, 000 acres (refer to the attached figure 1)

6.1.2 Topography, geology and soil

Nariva area can be roughly divided into the following 4 zones. Topographical, geological and soil conditions in each zone shall be described hereunder:

	Topographical condition	Geology	Soil
A.	Flat behind the natural beach bank running along the eastern cast line (consisting of the coconut plantations): This zone is lower than the high-tide level, and submerged throughout the year.	Alluvium	Mostly day, and partly sand and peat
B.	River flat higher than the high-tide level: This flat is submerged with the flood of rivers in rainy season	Alluvium	Mostly clay
C.	Slightly higher island-shaped ground in the flat mentioned in the above B.: This ground is covered with forest.	Alluvium and tertiary	Mostly clay and partly sand
D.	Hill slope zone surrounding the above zones.	Tertiary	Clay

In a strict meaning, the Nariva swamp area belongs to the above A - C zones. Its acreage is not 60,000 acres, but approx. 40,000 acres.

6.1.3 Land utilization at present

Except the northen Plum-Mitan area, only the extremely limited portion of land is cultivated at present. The Plum-Mitan area seems to have been early developed, because it belongs to the B zone of the above division, which was easily accessible from the existings road. But the land utilization in this area is not satisfactory. On the hill slopes around the Nariva swamp area, i.e. in the D zone of the above division, there are estates of cacao and citrus. In the land of favorable condition in the swamp, rice is grown in rainy season, while the water-melon, tomato, etc. are raised in dry season. But the rice and vegetable crops are not necessarily conducted on the same land. Exception the Plum-Mitan areas, these cultivations are mostly conducted by farmers, who broke into these areas without permission. Most of the Nariva area remains an unused wasteland. As for the land utilization other than the agriculture, only some fishing (chiefly the fish called the "Cascadura) and hunting are conducted.

Though the oil boring was conducted in the southern part of Nariva area, no oil production seems to have been recorded.

6.1.4 Hydrology

The yearly mean rainfall is approx. 90 inches. In rainy season from May to December, it rains mostly, Dry season is between January and April. Especially in February and March, it rains little, and the rain effective in the agriculture cannot be expected.

The rain is generally a heavy rain for a short time. In the sunshine time, there is only a small difference between the rainy and dry seasons. The temperature is as high as approx. 80°F on the average. Thoughout the year, therefore, it is suitable for the cultivation of almost all farm products. In this connection, the only limiting factor of the growing of crops in this area would be the water. Water control is, therefore, a key to the agricultural development in this area.

Several large rivers flow into this area. But their basins are not so large, slopes are steep, and the rain is of shower type as mentioned above. Therefore, the rain water flows off rapidly for a short time. Except two or three rivers flowing into this area, most of the rivers are small rivers, in which no flow is usually observed even in rainy season. If it once rains, however, these small rivers increase their flow suddenly, and torrents of water flow down to flood the adjacent area. From such a reason, even the land considerably high above the sea level looks like a swamp. If such a flow of rain water for several hours comes to an end, these rivers are restored to small rivers of no water flow. Such a rapid change in the flow of rivers indicates that the base-flow due to water conservation of underground water, etc. is very small.

Water, which flowed into the Nariva area as mentioned above, is gathered and stored for a time in the lowland behind the Beach Bank of the east side, i.e. in the A and B zones.

The only outlet of the water from the Nariva area to the outside, i.e. the sea is the mouth of the Nariva river. This mouth has not been silted up, and remain opened.

6.2 Development project

It is the water which has restricted the agricultural development in the Nariva area. In other words, the water control is just a fundamental problem to be solved in the development of the Nariva area.

6.2.1 Drainage program

The basic construction work for the development of Nariva area is the excavation of drainage canal. The drainage program for this area chiefly including the construction of drainage canals should be worked out in combination with the treatment of rivers flowing into this area.

In considering the drainage project, we have obtained the following fundamental ideas:

(a) Between the farm land and the open sea, regulating reservior is considered. The so-called double dike system are given. The farm land is surrounded by low bank (which is mostly used as the bank of river or drainage canal). Water coming from the farm land is discharged into the main drainage canal and regulatings reservoir through the watergate on the bank by virtue of gravity, or sometimes pump additionally installed. As the first bank fronting the open Atlantic sea, the existing Beach bank is used as before.

(b) Water flowing out of the ambient hills is received by the catch drain, and discharged into the sea by way of the main drainage canal and regulating reservoir. Water from the central mountain range flows in the Navet river at present. It is directly led to the main drainage canal, and discharged into the sea at the minimum distance.

(c) Drain from the Nariva area to the sea is controlled by the relation between the water level of the regulating reservoir, and the tidal level of the sea. In this connection, a regulating watergate is laid near the present mouth of Nariva river to prevent the sea water when the tidal level is higher than the water level of the inside, and to control the water level of regulating reservoir according the water storage program for irrigation. (According to the record of more detailed investigation in future, pump would be laid to increase the drainage capacity) The mouth of Nariva river is not silted up throughout the year, and requires no maintenance probably because various conditions at the mouth of river are balanced. If the drain program is put into practice, the present balance would make some change, this situation must be examined for the future.

(d) In planning the draivage facilities, we have assumed a large rainfall, which would cause once every approx. 100 years.

6.2.2 Irrigation program

Irrigation program is worked out as follows:

In rainy season, when the rainfall is inconstant and a long spell of drought days continues, supplementary irrigation is given, while the whole water reguirement is not within the reservoir capacity limit economically justified in dry season in anticipation of drought which would be probably observed once every 10 years.

The water requirement is assumed on the following standards:

Rainy season (in case of rice crops) 0.4 inch/day

Dry season (in case of vegetable crops) 1.2 inches

per a time, intermittent irrigation every 10 days

(The above water requirement must be examined in the future survey)

As for the water source, the regulating reservoir and main drainage canal, which was mentioned in the drainage program, are considered as a water storage system. Water is taken in by water gate or pump (which is also used for the drainage) for the irrigation. The capacity of regulating reservoir has been rather decided from a view point of the storage of irrigation water, not from that of the temporary storage of excessive water in the drain program. In view of the irrigation program, it is necessary to give a supplementary irrigation in rainy season, store the flowing excessive water in the reservoir, and carry it over to the dry season. From this point of view, it is natural to consider the building of a reservoir on the upper stream of river. On the upper course of the rivers flowing into the Nariva area, however, there seems to be no point, which could economically justify the building of reservoir. In this connection, we have decided to utilize the regulating reservoir laid in the lowland of this area. (We have taken it necessary to make further researches in the plan of building a dam on the upper stream area. In this case, it would be necessary to consider a multipurpose dam, which would be used not only for the water storage for irrigation but also for the water supply, recreation, etc.)

In relation to the scale of a regulating reservoir on the lowland, we have examined it from the aspects of drainage and irrigation. In conclusion, the security of

irrigation water (especially in dry season) has become a large factor of the decision of capacity. But the too large capacity of the reservoir would not be economically justified in the land utilization, because it would decrease the acreage of the land to be cultivated. In this connection, such value factors as the acreage of the farm land to be developed, production from this farm, water requirement (in rainy and dry season), required area of the reservoir, cost for the construction work, etc. must be decided so that the maximum efficiency may be obtained. Though it is located outside the Nariva area, meanwhile, there is the Ortoire river on the southern part of the area. It is the second large river, from which a considerable rate of flow can be expected. It is, therefore, possible to pump the water from this river into the regulating reservoir. In relation to the crop pattern and water requirement in future, we should like to investigate this plan.

The program we have recently suggested is decided on many assumption. It is, therefore, not a perfect and final program.

6.2.3 Disposition of the roads and villages, and the land development

In order to reduce the cost for construction as much as possible, banks of the canals are used as the roads. In consideration of the topography, meanwhile, the major roads are connected at a proper point to couple the existing villages with the market.

Villages, public facilities, storehouses, rice mill, etc. shall be arranged at the foot zone of hill slopes around the area, or in the high forest region of the area, i.e. C district (Sand Hill, Bush-bush, Bois Neuf, etc.) so as not to be flooded, when the rainfall is more than expected.

In principle, the irrigation canal shall not be used as a drainage canal.

Division, shape and the size of farms are dependent upon the level of agricultural technology to be applied to this area, especially the size of agricultural machinery implements, kind of the crops, drainage condition based on the soil quality, etc. In the recent survey, therefore, no detail has not been decided. General layout is shown in the general plan (attached Fig. 2)

6.2.4 Land utilization program

In working out the land utilization program, the area was classified into the districts according to the present topography and soil condition, and it was assumed that the drainage condition of these districts would be improved.

When the swamp is developed into an useful farm in the tropics, the most stabilized and economic crop is the rice plant. This would be comprehensible from the intrinsic nature of rice plant. Our basic idea of the land utilization program in the Nariva area is, therefore, as follows: In rainy season, rice is cropped chiefly, while the upland crops (e.g. vegetables, beans, etc.) are cultivated within the limit of the supply of irrigation water in dry season. On some hill slopes near the flat, meanwhile, beef cows are bred. If the upland crops are grown in such a lowland as the Nariva area in rainy season, the scale of drainage works would be larger. In addition, when the rainfall condition is considered, the profitability of the cultivation of upland crops would not be so high. In some local district of good topographical condition, however, the growing of upland crops would be possible even the rainy season.

Many people are of opinion that rice production should not positively be promoted for the reason of the trade relation to Guiana, and the productivity in this country. But we consider that there is no alternative but the paddy rice crop in rainy season to develope and utilize the Nariva swamp area ecomically. Furthermore, the rice has a large weight in the consitution of the food in this country. There is a trend of the rice consumption per head having increased in recent years. Even under such circumstances, most of the rice consumption has been imported.

Hill slopes around the flat shall be utilized as the forest and village district. The forest should be then utilized not only as a timber forest but also on estate of trees such as the cacao, citrus, coffee, etc.

The flat in the area, 40,000 acres can be roughly divided in terms of the utilization purpose as follows:

Farm land	24,500	acres
Grass land	7,500	"
Road, canal, regulating reservoir, etc.	8,000	"

6.2.5 How to promote the development

If the overall development of Nariva area is not conducted at a single stroke, but the partial development is promoted, the improvement project for the Plum-Mitan district should be firstly completed. It is desirable to start the development of the highland of the west side in the second place.

Even when the highland of the west side is developed, it is desirable to build firstly the regulating sluice, a drain outlet to the sea and the main drainage canal in preparation for the final project scale to prevent the double investment in the future development. In deciding this point, however, further detailed investigation into the order and period of the development of Nariva area should be made.

6.3 Economic valuation

6.3.1 Rough estimate of the cost for the work cost necessary for the development work of the Nariva area is roughly estimated as follows:

56.4×10^6 T.T. dollar

(33.18×10^6 U.S. dollars)

As no topographical map of high accuracy was made available, and our survey was made for a limited period, the above cost is a very rough estimate. In the meantime, this cost does not include the cost for building the experiment form, villages and the related facilities.

6.3.2 Benefit and cost ratio

If it is assumed that the life of facilities is 50 years, the ratio becomes 1.19 when the interest is 6% and it becomes 1.81 when the interest is 3%.

6.4 Study required in future

In our report, we have made a preliminary study of the feasibility of the development of Nariva area. From a technical and economic viewpoint, we have found it promising to develop the Nariva area into farm land. In deciding a concrete development project, however, the present data are very unsatisfactory.

Except the rainfall record and some soil survey record, the data made available at present are almost useless.

In connection with the above, it is necessary to make the large-scale maps, make detailed soil and hydrological (discharge of the rivers, tidal level, etc.) surveys. In order to work out a concrete development project, feasibility study must be put into practice. It is, accordingly, necessary for approx. 10 expert engineers to make the surveys for approx. 2 months in dry season. In this case, it is desirable to work out the topographical maps prior to the survey, and to make the hydrological survey for a considerably long period.

7. Conclusions and recommendations

7.1 Conclusions

(a) In view of the long-range agricultural policy of this country, the development of the Nariva area into farm land is highly necessary.

(b) When the cost necessary for the development work, and the benefit accruing from the development are considered together, the development of the Nariva area has a high posibility.

(c) Basic work of the development in the Nariva area is the drainage. This drainage program should be put into practice in combination with the treatment of rivers flowing into this area.

(d) Data made available at present are too unsatisfactory to decide a concrete development project.

7.2 Recommendations

7.2.1 In order to work out a concrete development program, fundamental data must be immediately prepared.

(a) As a fundamental of the project making, maps shall be made (scale: 1/50,000 and 1/1,000 or 1/2,000; space of the contour lines in the 1/1,000 - 1/2,000 - scale maps shall be 1 ft.)

(b) More detailed soil survey shall be made to classify the land in combination with the topographical and water conditions, and establish the future land utilization program.

(c) Run off of the rivers, water level in the swamp, tidal level at the mouth of Nariva river, and the sand drift shall be measured.

7.2.2 In order to work out the development project, it is advisable to make a feasibility study, which would require the survey for no less than 2 months in dry season conducted by approx. 10 expert engineers.

(a) Soil survey mentioned in the above item 7.2.1 can be also made in this feasibility study. In this soil survey, large co-operation could be expected from the staff and facilities of University of West Indies.

(b) It is desirable to make the topographical maps prior to this feasibility study.

(c) The hydrological measurement should be start early, because it can enhance the accuracy of the project, when the period of its data is longer. It is, therefore, desirable for the Government to start the hydrological measurement as early as possible.

7.2.3 Establishment of the experiment farm

It is desirable to set up an experiment farm in the area to make practical researches into the crops suitable to the Nariva area, cultivation method, and the proper water

requirement. As a site for the experiment farm, the Plum-Mitan district, which has been partly developed, would be proper.

7.2.4 Training of farmers, and the extension of farming technique

When the development of the Nariva area is realized, many farmers would settle in this area to conduct a new farming.

It is, therefore, necessary to give them education of new farming technology and consider its extension among them.

7.2.5 When the development of Nariva area is considered as part of the agricultural policy of the whole country, it is necessary to study how to estimate the development period, order, scale, etc., because this would become an important issue in deciding the annual program for the practice of the work, and the financial program, when the development project for the Nariva area is materialized.

8. Acknowledgements

The survey team of the Japanese Government hereby expresses hearty thanks to the Trinidad and Tobago government officials, professors of University of West Indies, and members of the private companies, who have given valuable aids and co-operation in the tender of various data and in the execution of the survey throughout the whole period of the recent survey of Nariva area.

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CHAPTER II GENERAL CONDITION

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Chapter II General condition

1. Natural condition

1.1 Location and the condition

Trinidad Island lies between the Atlantic Ocean on the east and the Caribbean Sea on the west. It is on the southeast end of West Indies, and only 10 miles off the Palia Peninsula of Venezuela in South America. It is located in latitude 10° 00' - 10°50' North and in longitude 60° - 61° West, and belongs to the tropical zone. The Nariva area we have recently surveyed is a low swamp area almost in the middle of the eastern part of Trinidad, which extends over the land behind the Cocos bay fronting the Atlantic. The area is approx. 45 miles off the capital, Port of Spain on the south coast. Such a distance can be covered in one hour and half by motorcar. The Nariva area forms a triangle with its base on the south, and its vertex on the north. Many rivers and valleys flowing from the Central range into the Nariva area. No distinct watercourse is, therefore, found in the Swamp. The Nariva river is the only outlet of run off into the Atlantic Ocean.

The Nariva swamp area is chiefly a grassland. Island-shaped hill in this area forms a forest. The northern part of this area is surrounded by the Lower Manzanilla road, the western by the Plum-Mitan and Cunapo Southern roads, the southern by the Rio Claro-Mayaro road, and the eastern by the dune area called the "Cocal" fronting the Atlantic where there are coconut plantations. The total acreage of this area is approx. 60,000 acres. The pure swamp is approx. 40,000 acres, and the rest forms slopes of the hill approx. 30 ft. above the lowland level.

In the area, there is no crossroad, but some paths, which give an access of no more than several miles to the ambient road, and allow no further passage ahead.

As for the land utilization, this area is chiefly used for hunting and fishing. As for the farm land, the Plum-Mitan and some other part are used for the rice growing. On the other hand, hill slopes are used as the plantation of trees such as the cocoa, etc. The low

swamp area, approx. 40,000 acres is little utilized.

1.2 Weather

Trinidad Island belongs to the tropics in latitude approx. 10° North. In relation to the weather condition, therefore, the Island has a character peculiar to the tropics as well as a sea character, as it is on the Atlantic.

(a) Rainfall and the sunshine time

Mean annual rainfall in the eastern part of Trinidad Island, where the Nariva area is located, is approx. 90.5 inches as shown in the following Table 1. In reference to the distribution of rainfall, the period from June to December forms the so-called rainy season, when much rainfall is observed, while the period from January to May forms the so-called dry season, when the rainfall is less than half of that in rainy season. Even in dry season, however, there is no month, when no rainfall is observed. Rain is a shower for short time peculiar to the tropics. This is conceivable from the following Table 1 showing the monthly sunshine time, where there is only a small difference between the rainy and dry seansons in the sunshine time.

Table 1: Average rainfall and the sunshiny time

Rainfall	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Eastern part	90.5 in	5.9	2.9	3.0	3.7	6.1	9.4	10.4	9.9	8.2	8.3	10.6	12.2
Western part	67.4 in	3.2	1.6	1.7	2.2	3.9	7.7	8.8	9.4	7.5	6.8	7.9	6.7
Sunshine time	7.6 hr.	8.2	8.8	8.3	7.7	5.3	7.2	7.4	7.9	6.1	9.1	6.5	8.3

Note: According to the Annual Statistical Digest, 1963 issued by the Central Statistic Office

(b) Temperature

Mean annual temperature is 88° F at maximum and 72° F at minimum. Monthly change is hardly observed. As the breeze blows constantly, however, man can

easily bear the heat, when he enters the shade. At night, too, temperature decreases to less than 80^{o} F so that the condition is very comfortable.

1.3 Geology

Nariva area is a low flat surrounded by the central uplift consisting of older formations such the Cretaceous, Palaeogene, etc. on the north side, the gentle low hill of syncline structure consisting of Palaeogene on the west side, and the south Caracadoux anticline consisting of Palaeogene or Neogene. Most of the area is made of swamp. Rivers flow from the basin of such geological structure as mentioned above into the Nariva area.

On the north side of river basin, there are the older Cretaceous Cuche formation, and the Pointe-A-Pieno formation of Palaeogene Gocene system, partly mixed with the Braso formation of Neogene. On the low hill of west side, Nariva formation of Palaeogene Oligocesse is widely distributed. Hill of complicated shape on the south side is made of newer formations such as the Leugua, Crush and Porest of Neogene miocene. Along the Cocal bay of the east side, Sand dune extends in the south-north direction in a shape of hill, and checks the drain of the inland. Rivers flowing from the rear mountains and hills settle the silt behind the dune to form a flat alluvion. The east part of this alluvion is almost on the same level as the coast, and this area is poor-drained to form a swamp, part of which has become a tidal compartment.

1.4 Topography

This area can be roughly divided into the following 4 districts topographically:

A. Flat behind the natural beach bank (forming the coconut estates at present) running along the eastern coast line: This district is lower than the high-tide level so that it is submerged throughout the year. In a narrow section east of this district (just behind of the beach bank), there are peat deposits.

B. Riverflat higher than the high-tide level: This district is flooded with rivers in rainy season.

C. Slightly high island-like district in the B flat: Sand Hills, Bush-bush, Bon Neuf, etc. belong to this district, which is covered with forest.

D. All the hill districts surrounding the above districts. They range to the central mountains.

1.5 Soil and vegetation

General condition of the soil and vegetation in this area is almost as shown in the Tables 2 and 3.

In these Tables, not only the soil but also the present vegetation are divided in terms of deposits and drainage conditions. As the alluvion effect is made by the rivers flowing from the mountains of hinterland, which is made of highly clayish formation, all the deposits carried over are also clayish, and no gravel is observed.

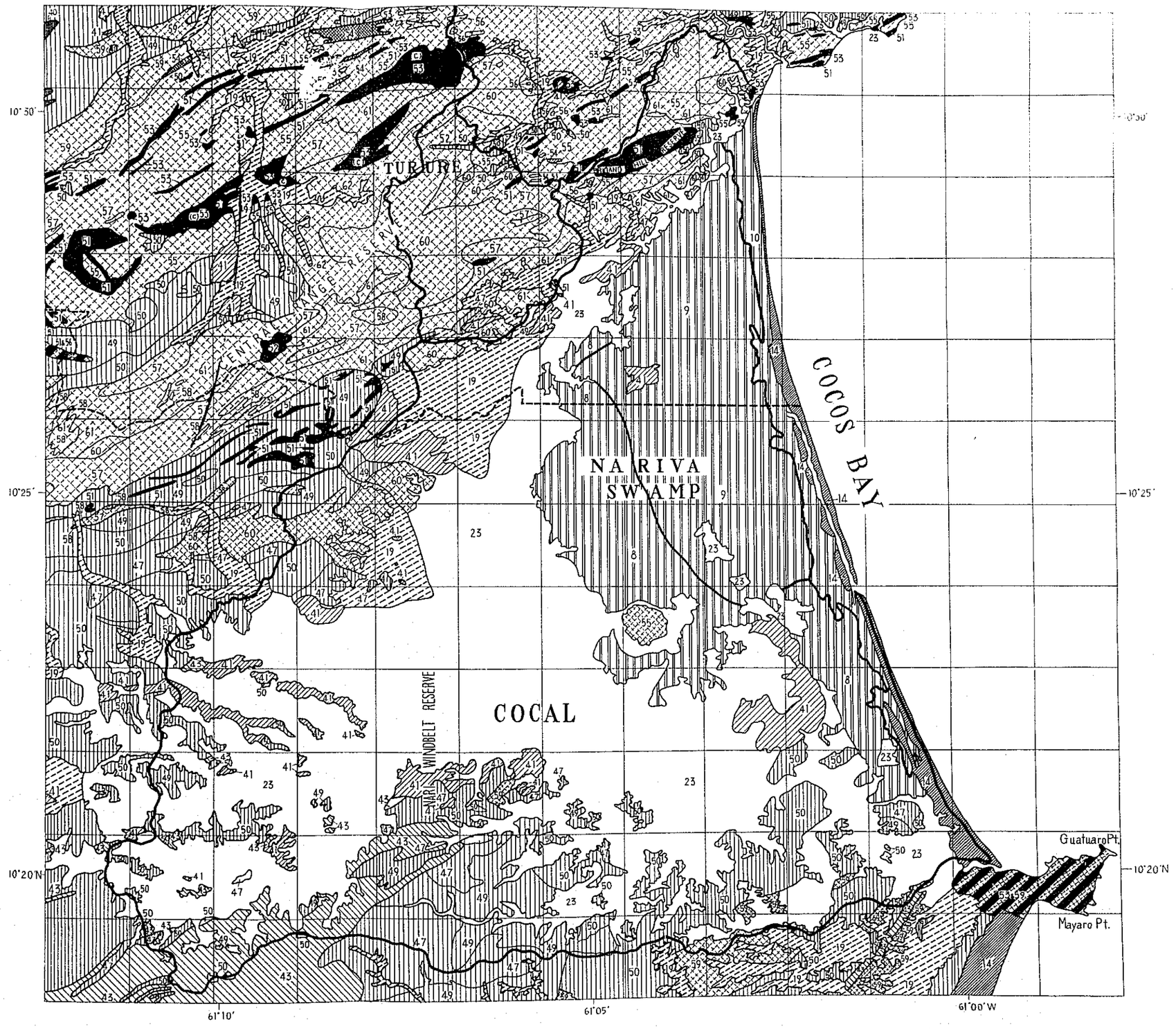
On the flood plain, which was flatted by rivers flowing among the hills behind the swamp, mottled river alluvial clays are distributed. The district, where the river extends from the hills to the alluvial lowland, is covered with forest, and the mottled swamp alluvial clays affected by forest are observed. This kind of soil account for approx. 58% of this area. The districts near the coast, or surrounded by the northern hills, which are poor-drained, form the grassland, and the mottled swamp clays affected by the grassland are observed. In the tidal compartment or the near-by areas, such slightly high dunes as the Sand Hill, Bush-bush, etc. are observed exceptionally. But a low and flat grassland of uniform swamp clays is generally made by deposits of much clays flowing from the valleys of rivers. On the higher land around the rivers flowing from the old formation north of the alluvion, fertile fine and sandy clays are distributed. Along the coast, there are deposits of sandy loam originating from the dune. On the inside of the dune affected by the swamp, formation of peat is observed, and partly the peaty clays are found. As for the vegetation, the hinterland hills ranging from the alluvion of river valleys to the higher alluvion are covered with forest, while the swamp near the coast forms a grassland. The greater part of the district in the northern region of the area, where fine sandy clays are distributed, is also a poor-drained

NARIVA SWAMP

NO.	FIG Soil map
DATE	12 - 1966

OVERSEAS TECHNICAL COOPERATION AGENCY JAPAN

MINISTRY OF AGRICULTURE & FORESTRY, JAPAN



54 Montserrat Clay

51 Tamana Clay
52 San Fernando Sand
53 Mayaro Sands

55 Brasso Clay
56 Marper Clays
57 Canteybury Silty Clay
58 Biche Clay
59 Moniga Loams
60 Mt. Harris Catena
61 Mitan Loams
62 Chaudiere Clay

47 Tarouba Clay
49 Ecclesville Clay
50 Talparo Clay

43 Princes Town Clay

41 Las Lomas Sandland Loams

40 Arena Sand

23 Naret Clay

19 L'Ebranche Clays

14 Cocal Fine Sand

8 Bois Neuf Clay
10 Macaw Peaty Clay
9 Nariva Swamp Clay

grassland. But part of the Plum-Mitan area, etc. is used as the paddy field, while the relatively well-drained district is used for the growing of cocoa, etc. Hill of the coast is utilized for the coconut plantation.

Table 2: Classification of the soil and the growing plants

Name of the Soil	Acres	Acres %	Vegetation
1 Highly productive silty clays	3, 436	5.2	grassland, partially cultivated land
2 Anottles riven allwoval chays	2, 372	3.6	forest
3 Mattles swamp clays under forest	34, 707	52.8	forest
4 Mattles swamp clays under savanna	7, 692	11.6	grassland
5 Uniform swamp clays under savanna	9, 432	14.2	grassland " flood area
6 Peaty clays under mangrove	908	1.4	forest
7 Sands under swamp	244	0.4	grassland
8 Marine sands	1, 565	2.3	grassland
9 Hilly silty clays	5, 644	8.5	forest
	66, 000	100	

Note: The areas distributed by the soil 3 ~ 7 are flooded in the season of inundation.

Table 3: Area classified by soil (refer to the Fig. 1)

Number of the Soil	Acres	Acres %
8	5, 590	8.4
9	7, 850	11.8
10	1, 652	2.5
14	1, 150	1.7
19	3, 790	4.4
23	31, 100	46.7
41	2, 120	3.8
43	1, 810	2.6
47	2, 030	3.1
49	2, 490	3.8
50	3, 580	4.9
51	360	0.5
53	40	0.06
55	1, 100	1.6
56	90	0.1
57	350	0.5
58	20	0.0
59	510	0.5
60	1, 260	1.9
61	570	0.9
Total	66, 300	100.0

1.6 Land classification

In order to define the possibility of land utilization, it is necessary to make a land classification survey. But we could not complete this survey because our recent survey was conducted for a short period, and the rainy season made it impossible for us to make a survey of many districts. On the basis of the existing data and our on-the-spot survey, we shall hereunder give the summary of our survey records. In relation to the classification of slope and drainage, we have employed the classification of land utilization feasibility used in the University of West Indies. In relation of the classification of soil quality, meanwhile, we have employed the classification in the land development project survey in Japan.

1.6.1 Classification factors and standard

(a) Slope

Sign	Gradient	Applicable classification standard
A	$0 \sim 2^{\circ}$	I
B	$2 \sim 5^{\circ}$	II
C	$5 \sim 10^{\circ}$	III
D	$10 \sim 20^{\circ}$	IV
E	$20 \sim 30^{\circ}$	V
F	$30^{\circ} <$	V

(b) Soil quality

Sign		Soil series no. (refer to the Fig. 1)	Class
1	Loam soil	41, 59	I
2	Clayish soil	8, 9, 19, 23, 43, 47, 49, 50, 55, 60	II
3	Sandy soil	14	III
4	Peaty soil	10	IV

(c) Draining condition

Sign		Class
1	Drains well (throughout the year)	I

Sign		Class
2	Drains slightly poor (well in dry season, but submerged in rainy season)	II
3	Drains poor (usually submerged in rainy season)	III
4	Drains very poor (submerged throughout the year)	IV

1.6.2 Expression in the illustrations

	Soil quality	Gradient	Drain condition
Example:	1	A	2

1.6.3 Classification standard

I-class land --- Land of highest productivity, on which no restriction is imposed, when it is used as an arable land

II-class land --- Land of high productivity, where some restrictions are placed on the crops, development and the land improvement, when it is used as an arable land

III-class land --- Land where strict restrictions are imposed on the crops, development and the land improvement, when it is used as an arable land

IV-class land --- Barren land, which shall be utilized as forest or grassland

V-class land --- Barren land, on which some restrictions are imposed, even when it is used as the forest or grassland

If any of the classification standards shown in the above (a), (b) and (c) is lower than the above, it shall be of the same class as the latter.

When the rough classification was given in the above way, drainage condition has become a major factor for deciding the class of land. From this fact, it is conceivable that the improvement of drainage is a fundamental condition for the development of this area.

1.7 Water quality and temperature

At the survey point, water quality and temperature of the river flowing into the

Nariva swamp area were as follows. Except at the mouth of Nariva river, water can be used for irrigation.

Water temperature: $58^{o}F$

Water quality:

Salt density at the mouth of Nariva river; 0.4%

Salt density at the other points; 0.015 ~ 0.03%

2. Social and economic condition

2.1 Population

According to the census in 1960, total population of Trinidad and Tobago is approx. 828,000. It can be divided as follows:

Negro	359,000	42%
East Indian	302,000	37%
Whites	16,000	2%
Mixed	135,000	17%
Chinese	8,600	1%
Others		1%

(Refer to the attached Fig. 3)

Population has yearly increased by 26,000 ~ 28,000 at the rate of more than 3%. It is estimated that the population would be approx. 1,150,000 in 1971, when it increases at the above rate. Even at present, the unemployment ratio is as high as 14%. Thus the unemployment has become an important social problem in this country.

The population of the Nariva county occupying the greater part of this area is 17,000, approx. 2% of the total. As the acreage of the Nariva county is 132,000 acres, equivalent to 10% of the total, however, the population density is 1/5 of the nation-wide ratio. This has disclosed that this area is very sparsely populated.

2.2 Economic condition

In 1956, the exports and imports of Trinidad and Tobago totaled approx. T.T.$ 300,000,000 respectively, and were balanced with each other. In 1965, when the imports were T.T.$ 813,000,000, and the exports were T.T.$ 673,000,000, the excess of imports over exports was approx. T.T.$ 140,000,000 (refer to the Table 4). In the imports, imports of the foodstuffs had a share of approx. 10% (T.T.$ 87,000,000). In view of the population increase and the current food supply condition, therefore, it is evident that the food imports would increase in future. Thus the food import is a problem, against which proper measures should be considered in earnest.

Except the products such as the sugar, coffee, bean, grape fruit, only small amount of vegetable, etc., most of the agricultural products consumed in Trinidad and Tobago are fully dependent upon the import. Principal imported agricultural products are almost as follows:

Wheat flour	T.T.$ 13,000,000
Butter, cheese and milk	T.T.$730,000,000
Rice	T.T.$ 9,000,000 (approx. 30,000 tons)
Corn	T.T.$ 21,000,000
Garlic	T.T.$ 2,000,000
Onion	T.T.$ 7,000,000
Soybean	T.T.$ 15,000,000 (6,000 tons)
Others	
Total	T.T.$875,000,000 (1965)

Fig. 2 Trend of the exports and imports

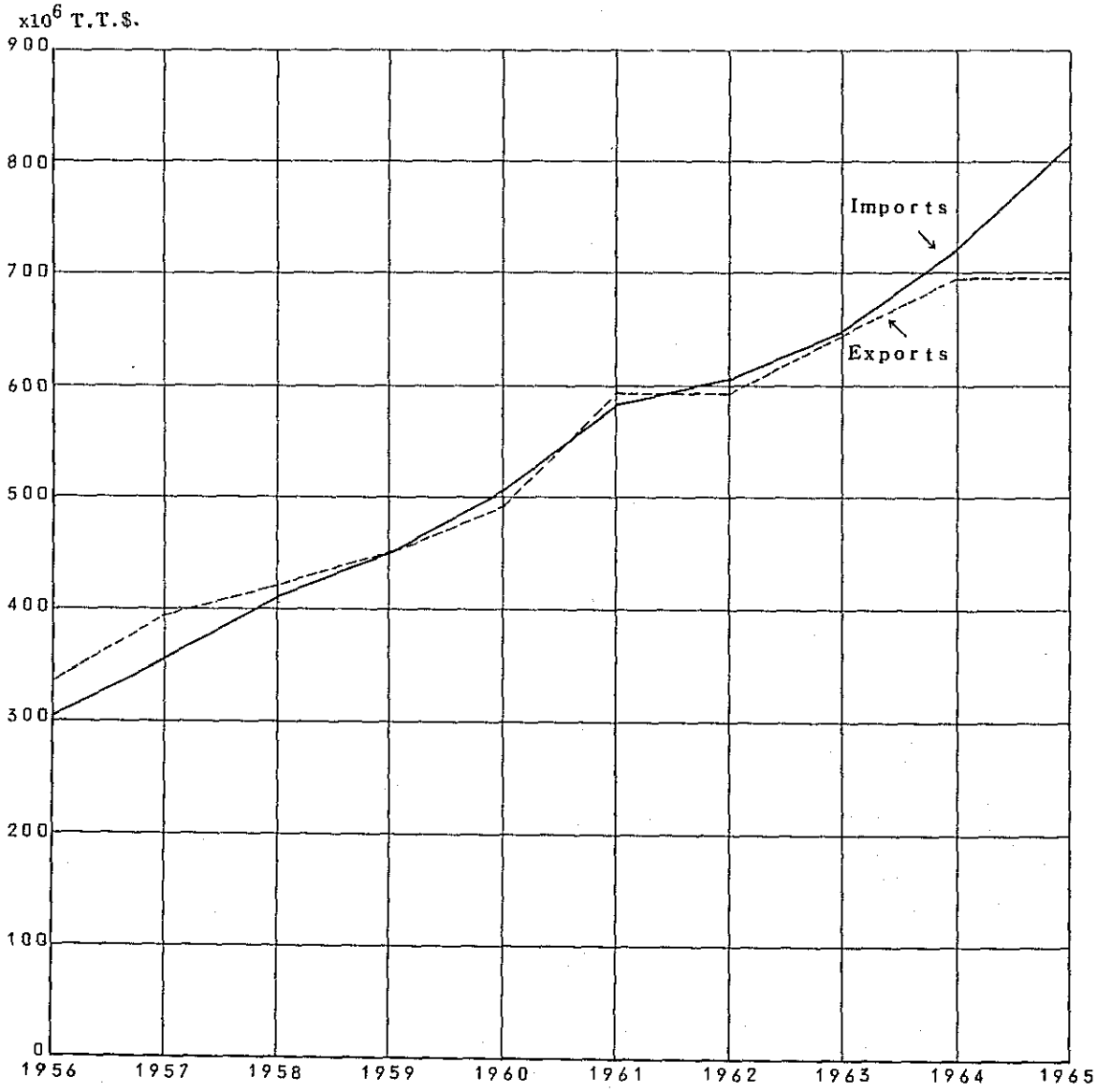


Table 4: Condition of the export and import in foreign trade

Period	Export of domestic Produce	Export of Foreign Produce	Total Exports	Total Imports	Balance of Visible Trade
	(1) 000$	(2) 000$	(3) 000$	(4) 000$	(5) 000$
1961	579, 528	13, 926	593, 454	583, 978	+ 9, 476
1962	579, 622	12, 372	591, 994	605, 571	- 13, 577
1963	624, 630	16, 066	640, 696	646, 363	- 5, 667
1964	680, 394	13, 211	693, 606	724, 026	- 30, 240
1965	673, 187	14, 894	688, 087	812, 853	-124, 772
1966					

In the meantime, if the retailprice index is 100 in Sept. 1960, it tends to increase gradually as shown in the following table:

1961	101.1
1962	104.1
1963	108.1
1964	109.0
1965	110.9

3. General condition of the agriculture

3.1 General condition of the production

The acreage of farm land in Trinidad and Tobago is 415, 000 ares, approx, 33% of the total area of the country. Farm land acreage in the Nariva county including the greater part of Nariva area is 21, 912 acres, approx, 17% of the total acreage of Nariva county. As compared with the mean utilization rate in Trinidad and Tobago, the land utilization rate in the Nariva area is only approx. one half. The chiefreason for the low land utilization rate is evidently that the Nariva area, no less than 60, 000 acres remains undeveloped because of its poor drainage (refer to the Table 5).

Table 5: Area of the farm land classified by district

Name of Country	Acreage of the Country (A)	Acreage of the farms (more than 1 acre per farm)	$\frac{B}{A} \times 100$
Trinidad and Tobago	1, 267, 236	414, 937	32.7
St. Geoge	229, 509	55, 961	24.4
St. Andrew	180, 954	53, 093	29.3
Caroni	136, 951	82, 734	60.4
Victoria	202, 611	68, 938	34.0
St. Patrick	166, 912	59, 201	35.5
St. David	50, 530	16, 317	32.2
Nariva	132, 033	21, 912	16.6
Mayaro	93, 244	10, 017	10.7
Tobago	74, 392	46, 764	62.9

In the meantime, when the mean scale of the farmers in possession of farms, more than 1 acre each is observed, the ratio of farmers in possession of farms, less than 1 ~ 5 acres to the whole farmers, 30, 511 is 60%, and the ratio of those in possession of farms, 5 ~ 10 acres each is 20%. These two classes of farmers accounts for 80% of the total. On the other hand, their are farmers in possession of more than 1, 000 acres each. This there is a large difference among the farmers in the scale of their farms. These farmers in possession of large farms are those who are growing the coconut, coffee, cocoa, sugar cane, etc. (refer to the Table 6)

Table 6: Number of farmers classified by management scale (1946)

Total number of farmers	30, 511	100 %
1 ~ 5 acres	18, 000	60 "
5 ~ 10 "	6, 200	20 "
10 ~ 15 "	2, 400	8 "
20 ~ 30 "	1, 300	4 "
30 ~ 50 "	634	2 "
50 ~ 100 "	374	1 "
100 ~ 200 "	212	5 "
200 ~ 500 "	130	
500 ~ 1, 000 "	52	
> 1, 000 "	44	

As the recent data are not made available, the cultivating condition of each crop in Trinidad and Tobago is not unknown to us. According to the Land Utilization for Agricultural Production in 1956 (issued by the Central Statistical Office), the cultivating condition is as shown in the Table 7 and 8.

Table 7: Acreage under cultivation classified in terms of crops (1)

Total acreage for the tree crops		92, 400 acres
made up by	Cocoa	48, 300 "
	Coffee	3, 200 "
	Coconut	29, 500 "
	Citrus	8, 000 "
	Banana	700 "
	Tonca beans	1, 800 "
	Rubber	600 "
	Others	200 "

Table 8: Acreage under cultivation classified in terms of crops (2)

Total acreage for the upland crops		50, 450 acres
made up by	Sugar cane	47, 500 "
	Rice	1, 160 "
	Pineapple	10 "
	Corn	150 "
	Beans	70 "
	Ground provisions	100 "
	Vegetables	330 "
	Other edible crops	100 "
	Fodder	1, 030 "

Though the above statistics were made about 10 years ago, the present condition makes no great difference from them. From them, therefore, general aspect of the cultivation of various crops in this country is conceivable. The acreage under cultivation for the tree and upland crops for the domestic consumption is very small. For instance, coconut accounts for 96% of the acreage under cultivation for the tree crops, and the sugar cane 95% of that for the upland crops.

On the other hand, the cultivating condition of the majorcrops in Trinidad and Tobago is almost as follows. From this Table, we can generally conclude that most kinds of crops can be grown throughout the year. It is natural that the yield is higher due to the good care of crops and the good management of farms in the plant diseases and insect pests, when they are grown in dry season under the proper irrigation. Even in rainy season, considerable yield can be secured, when proper care is taken of the crops, and the farms are properly managed (refer to the Table 9)

Table 9: Outline of the cultivation of various crops

Name of the crop	Proper season for the growing	Growing period	Yield	Remark
Tomato	Whole year (dry season is better)	8 ~ 12 weeks	2 ~ 3 tons 1 ~ 2 tons	in dry season in rainy season
Cabbage	Whole year (dry season is better)	12 ~ 18 weeks	unknown	
Beans	Whole year	6 ~ 10 weeks	unknown	
Soybeans	Whole year (irrigated in dry season)	"	50 lb/acre	
Watermelon	Nov. ~ Apr.	7 weeks	unknown	Grown in the swamp
Cucumber		8 ~ 10 weeks	unknown	
Cow peas	Dec. ~ Mar.	12 ~ 16 weeks	60 ~ 18 lb/acre	usually grown in the paddy fields
Rice	Jul. ~ Nov.		1, 500 ~ 3, 000 lb/acre	transplanted once weeded and grown without fertilizer Indica s.
Corn	Whole year (October is better)	14 ~ 16 weeks	200 lb/acre	

3.2 Demand and supply of the major agricultural products

Demand and supply condition of the principal farming products is as follows:

3.2.1 Rice

Rice produced in Trinidad and Tobago has not become a commercial crop. At the present stage, rice is grown by farmers chiefly for their home use only. But the rice demand in this country is so large as shown in the following report on the survey of rice industry issued in Summer of 1953:

Table 10: Survey of the Rice Industry

Year	Population	Imports	Annual imports per head	Domestic production	Yearly consumption per head
1938	460, 300	19, 437 tons	94.6 lb.	6, 000 tons	124 lb.
1946	600, 000	12, 183	46.5	10, 000	84
1951	648, 700	14, 608	50.4	11, 160	89
1952	663, 600	14, 015	47.3	11, 500	86

Note: According to the Draft Second Five-year Plan (1964 ~ 1968) issued by the Government, the annual rice consumption per head, which was 86 lb. in 1955, has recently increased to 155 ~ 158 lb.

With the recent increase in population, the rice demand has thus shown an upward tendency. The rice import in 1966 is as much as T.T.$9, 000, 000. If the population in 1971 is estimated at 1, 115, 000, the rice import would be as much as 33, 000 tons.

3.2.2 Edible oil

Demand for the edible oil in this country is approx. 20, 000 tons. Domestic production of coconut oil, which had been 20, 000 tons per year, has recently decreased to approx. 13, 000 tons because of the occurrence of Red Ring disease in coconut trees. Of the balance, 7, 000 tons, approx. 6, 000 tons are dependent upon the import of soybean oil from U.S.A., except 1, 000 tons imported from the Caribbean islands.

3.2.3 Beet and others

Beet, approx. 7, 000, 000 lbs. amounting to T.T.$4, 000, 000 has been imported every year. Butter, cheese and milk, amounting to T.T.$30, 000, 000 has been yearly imported. Garlic coming up to T.T.$2, 000, 000 has been imported per annum.

3.2.4 Vegetables and others

Onion amounting to T.T.$7, 000, 000 has been imported per year.

Fruits are self-supplied.

Watermelon has been exported to U.S.A. in winter.

Grape fruit (including the juice) amounting to T.T.$2, 700, 000 has been annu-

ally exported.

Sugar	approx. T.T.$41,000,000	exported per year
Cocoa (bean),	approx. T.T.$ 4,000,000	
Coffee (bean),	approx. T.T.$ 3,000,000	

As mentioned above, almost all foodstuffs except several products such as the sugar, grape fruit, etc. are dependent upon the overseas markets.

CHAPTER III DEVELOPMENT PROJECT

Chapter III Development project

1. Land utilization program

1.1 Background

As the agricultural development project for the Nariva area covers a development acreage, 60,000 acres equivalent to 1/20 of the total area of the country, it would have an important influence upon the future agricultural policy in Trinidad and Tobago. In this connection, we shall hereunder summarize the natural condition in the Nariva area, and the social and economic condition in Trinidad and Tobago:

(a) The Nariva area consists of wide and low swamp and the surrounding hills of gentle slope. River basin acreage is almost the same as the acreage of the area. As the height above the sea level is very small, however, drainage condition is very bad in rainy season (Jun. ~ Nov.) when much rainfall is observed.

(b) Productivity of this area could be increased by the improvement of drainage and land reclamation.

(c) Except such farming products as the sugar, coffee, cocoa, grape fruit, etc., most of the foodstuffs are dependent upon the imports from over the seas.

(d) With the rapid population increase of this country amounting to 3% in every year, the imports of foodstuffs would also greatly increase in future.

(e) Balance of the international payments in Trinidad and Tobago has since 1961 become unfavorable, in 1965, unfavorable balance of trade was approx. more than T.T.$100,000,000. Considering the stagnation of oil production, a major export industry of this country, and the present condition of other industries, meanwhile, it would be very difficult to promote the export immediately.
From various viewpoints mentioned above, it would be reasonable to decide the fundamental policy of the development of this area into an agricultural farm land as follows:

1.2 Land utilization program

(a) As for the agricultural management, owner-farmer system shall be employed.

(b) This area is chiefly occupied by low swamps, whose development is fundamentally in need of drainage work. From a viewpoint of the economy of drainage work, it would be reasonable to make the paddy field mainly. This is also a high-efficient utilization of the productivity of land.

(c) At first, an overall development project for the whole area shall be worked out. In practice, however, it would be efficient to carry out each program as part of the whole project in sequence according to the circumstances.

On the basis of the above fundamental policy, we have defined the land utilization program for this area as follows:

Table 11: Acreage of the land classified in terms of utilization

Division	Acreage
Acreage of the survey area	66, 000 acres
Acreage of forest	26, 000 "
Total acreage of the area to be developed	40, 000 "
Farm land	24, 500 "
Glassland	7, 500 "
Roads, canals, regulating reservoir, etc.	8, 000 "

1.3 Estimate of the yield of crops

(a) Paddy rice --- According to the Draft Second Five-year Plan, 1964 ~ 1968 issued by the government authorities, unit yield is 2, 250 ~ 2, 500 lb./acre. If the land condition is improved by the drainage, more care is taken of the plants (weeding, fertilization, etc.), and the excellent variety is chosen, unit yield would increase to 3, 000 lb./acre.

(b) Soybean and corn

In relation to the soybean and corn, no data has been made available in this country. Considering the actual records in other areas of West Indies, however, it is expected that the yield of soybean would be 1,000 lb. per acre, and that of corn 2,000 lb.

On the basis of the above estimate of yield we shall hereunder study the management scale of farmers, and the cropping pattern, which conform to the land utilization program:

1.4 Study of a farmer who grows the paddy rice and soybean, breeds the beef cows

1.4.1 Cultivation of paddy rice and soybean

Paddy rice is chiefly cropped, and then the soybean is cropped. Cropping pattern is almost as shown hereunder:

	← Soybean →						← Paddy rice →					
Cropping pattern	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.

Yield of the paddy rice per acre 3,000 lb.

Yield of the soybean per acre 1,000 lb.

In case the selling prices of paddy rice and soybean on farms are the same as the import prices,

Unit price (per lb.) of the rice T.T.$0.13

" of the soybean T.T.$0.10

Approximate income per unit area (acre)

Rice T.T.$0.13 x 3,000 lb. = T.T.$390

Soybean T.T.$0.10 x 1,000 lb. = T.T.$100

Net income per unit area (acre)

Rice T.T.$390 × 0.69 = T.T.$269

Soybean T.T.$100 × 0.56 = T.T.$56

∴ T.T.$269 + T.T.$56 = T.T.$325

Note:

In relation to the base of the income rate of rice, soybean, the sole survey of rice production cost in this country is the "Rice Industry Survey" issued in 1953. According to this report, the ratio of rice production cost is approx. 47%. In other words, 53% of the price is the net profit. But this production cost does not include the cost of fertilizer. In our report, we have employed the income and profit rates, which are used in the agricultural development works in Japan. There seems to be a large difference between the agricultural production in this country and that in Japan in such components of the production as the fertilizer, machinery, labor, etc. It is, therefore, not correct to use the values in Japan. These points must be accordingly corrected in the future survey.

1) Income rate (percentage of the product price, from which other costs are subtracted, to the product price)

Rice	0.69
Soybean	0.56
Corn	0.69
Beef cow	0.5

2) Profit rate (percentage of the product price, from which the production cost is subtracted, to the product price)

Rice	0.39
Soybean	0.32
Corn	0.21
Beef cow	0.3

3) The above rates for the beef cow are based on our estimate. Other rates are based upon the recent statistical survey made in Japan.

(a) Acreage of the paddy field per farmer required to obtain an agricultural income, T.T.$3,000

T.T.$3,000 ÷ T.T.$325 = 9.3 ≒ 10 acres

(b) Production and its amount in case when the paddy field, 24,500 acres is developed

	Production	Amount
Rice	approx. 33,000 long tons	T.T.$ 9,555,000
Soybean	" 11,000 "	T.T.$ 2,450,000
Total		T.T.$12,005,000

As mentioned above, the planned rice production in Trinidad and Tobago is over the rice import at present. When the future population increase is considered, however, it would be a reasonable production target. The soybean production is equivalent to approx. 40% of the soybean imports of this country.

(c) Number of the farmer families, which could settle: 2,450

1.4.2 Breeding of the beef cows

Required grassland acreage per head ..... 1 acre

Weight per head (18-month old) ..... 1,320 lb.

Yield 0.27

Weight of the beef per head 1,320 lb × 0.27 = 356 lb.

In case the selling price of beef is the same as the import price, the price per lb. is ..... T.T.$0.60

Approximate income per head ..... T.T.$214

Income in case when the income rate is 0.5 ..... T.T.$107

Required grassland acreage and member of the bred cows for obtaining the income ..... T.T.$3,000

T.T.$3,000 ÷ T.T.$107 = 28 acres

$$28 \text{ acres} \times \frac{18 \text{ months}}{12 \text{ "}} = 32 \text{ acres}$$

Number of the bred cows 28 head $\times \frac{18}{12} = 32$ heads

Number of the farmer families, which could settle

7,500 acres ÷ 32 acres ≒ 215

Total production of the beef of cows bred by farmers 2,170,000 lb.

Total production amount of the above T.T.$1,300,000

The above production is equivalent to 30% of the beef imports of this country, 7,000,000 lb.

1.4.3 Total production

Rice	T.T.$ 9,550,000
Soybean	T.T.$ 2,450,000
Beef	T.T.$ 1,300,000
Total	T.T.$13,305,000

1.5 Study of a farmer, who grows the paddy rice and corn, and breeds the beef cows

Paddy rice is chiefly grown, and then the corn is cultivated. Cropping pattern is as shown hereunder:

	← Corn →						← Paddy land rice →					
Cropping pattern	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.

Yield of the paddy rice per unit area (acre) 3,000 lb.

Yield of the corn " 2,000 lb.

In case the selling prices of rice and corn at farmers are the same as the import prices,

Unit cost of the rice (per acre) T.T.$0.13

" of the corn (") T.T.$0.05

Approximate income per unit area

Rice (per acre)	T.T.$0.13 × 3,000 lb. =	T.T.$390
Corn (")	T.T.$0.05 × 2,000 lb. =	T.T.$100
Total		T.T.$490

Net income per unit area

Rice	T.T.$390 × 0.69 =	T.T.$273
Corn	T.T.$100 × 0.69 =	T.T.$69
Total		T.T.$342

Required paddy field acreage per farmer for obtaining the agricultural income,

T.T.$3,000

T.T.$3,000 ÷ T.T.$342 = 8.77 acres ≒ 9 acres

In case the paddy field, 24,500 acres is developed, production and values are as follows:

	Production	Production value
Rice	33,000 tons	T.T.$ 9,555,000
Corn	22,000 tons	T.T.$ 2,450,000
Total		T.T.$12,005,000

The above productions of rice and corn are above the rice import, approx. 30,000 tons and the corn import, approx. 20,000 tons in Trinidad and Tobago respectively.

Number of the farmer households, which could settle: 2,722

2. Drainage program

2.1 Topography

The Nariva area fronting the Atlantic Ocean is, as mentioned above (II. 1.4), divided into 4 blocs, which are distributed in stage and belt shape toward the coast.

We are told that this area is accessible on foot in dry season. From this fact, it is conceivable that most of this area would be dried in dry season. Inundated fields of this area in rainy season are 2 blocs of the lowland. Affected by the tide, these blocs of the lowland drainage poor to form swamps.

The largest of the rivers flowing into this area is the Navet river, the only river with its basic flow. In addition, there are approx. 15 rivers flowing into this area, which are so small as to flow, when it rains.

The observed topographical features of this drainage basin are that the river basin of this area is split by the Cunapo Southern Road running from north to south almost is the middle of the area, the flood flows down through the bridges and underdrains build on this road, and that the basin of the Navet river has become smaller, because the water of the upper stream is stored by the Navet dam, and diverged to the west coast area for the use of water supply (refer to the attached Map 1).

The total acreage of the river basin in the Nariva area is approx. 109,000 acres: The acreage of the area east of the Cunapo Southern Road is approx. 66,300 acres. Of it, the the flat land, i.e. swamp area covers approx. 40,000 acres.

If the condition of this river basin is observed from such viewpoint as mentioned above, the ratio of the flat land to the total basin area, is 1: approx. 2.7, while the ratio of the area east of the Cunapo Southern Road to the total acreage of the basin area is 1: approx. 1.6. From this smaller ratio, it is conceivable that this area can be easily drained.

In working out a development project for this area, it is necessary to consider the drainage at first. In this connection, we shall describe the rainfall and run off mechanism, elements of the drainage program in the followings:

2.2 Rainfall

Rainfall in Trinidad island is observed in 32 meteorological stations, which include the automatic rain gauges. Observation system is perfect. Isohyetal map, which is made from the mean monthly rainfall data obtained in the above stations, is as shown in the Fig. 3, average monthly rainfall in the Nariva area based upon these data is as shown in the Fig. 4. (These informations have been given by the Trinidad and Tobago Government.)

Fig.3 Isoheytal map

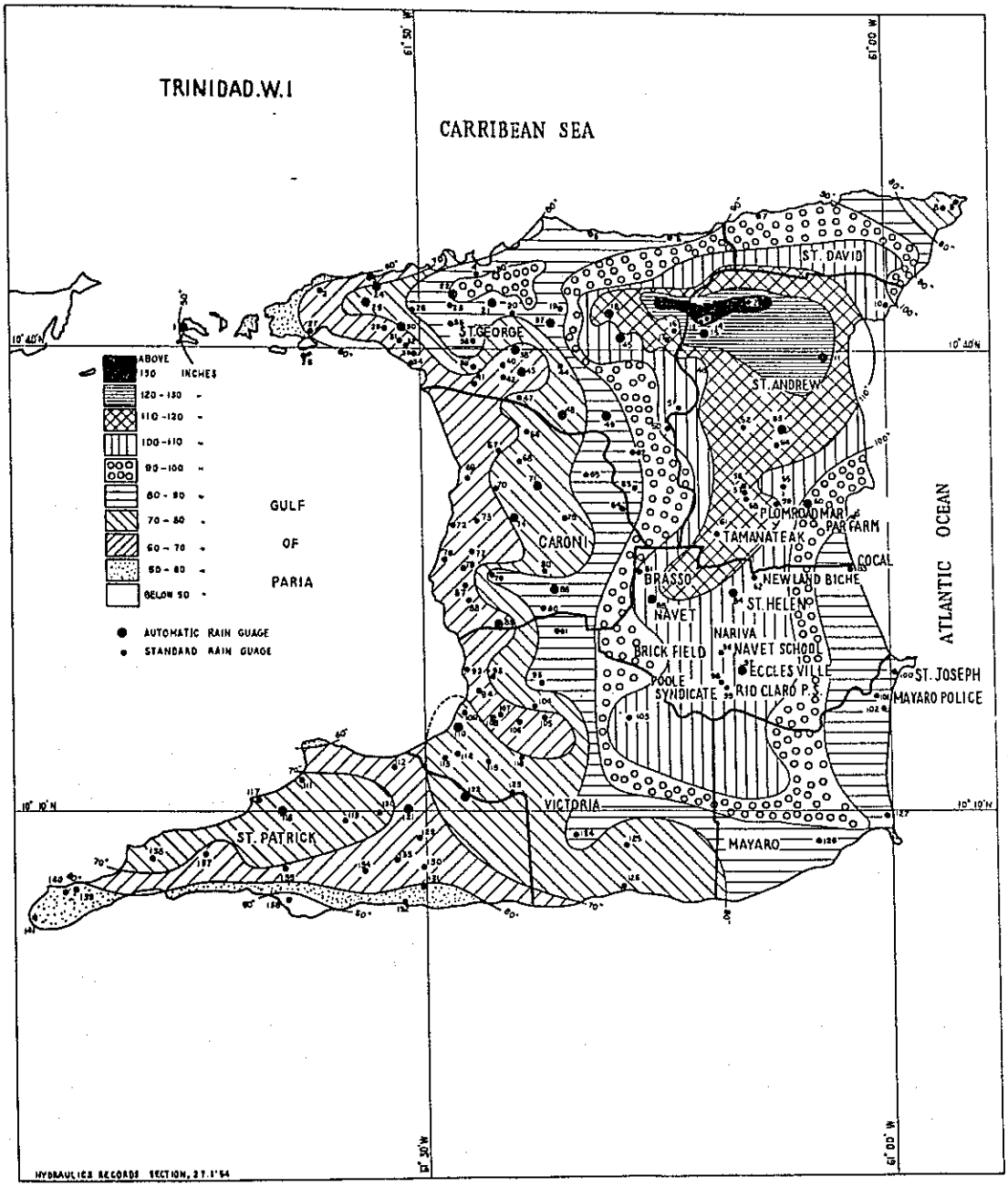
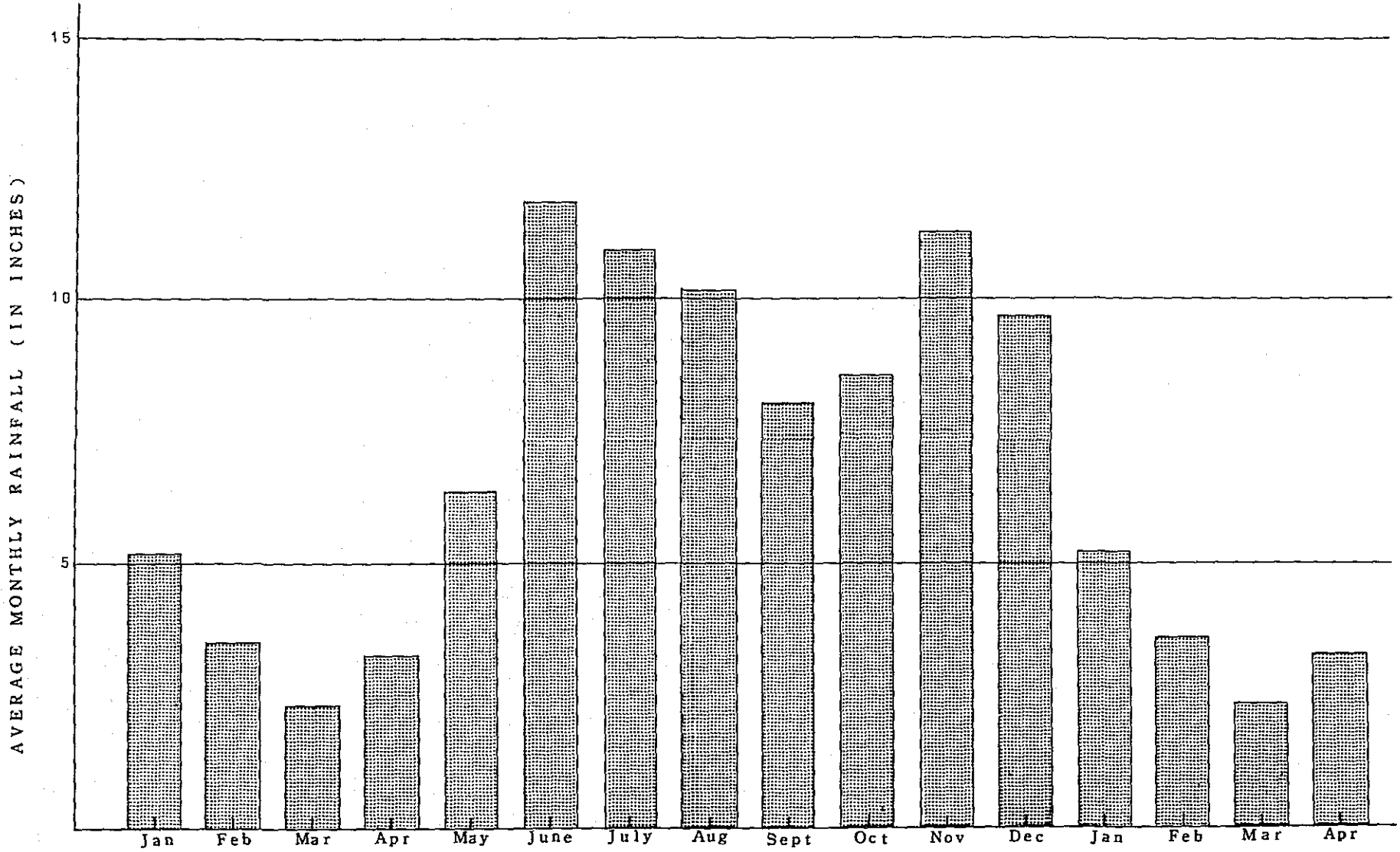


Fig. 4 Average monthly rainfall in the Nariva swamp area



2.3 Probability rainfall

When the general trend is observed on the basis of rainfall data in Trinidad Island, rainfall is larger in the Nariva area than in the area along the west coast. As for the rain time, it is a shower peculiar to this region. It rains heavily for several hours a day. There is little difference between the rainy and dry seasons in the sunshiny time. According to the data, rainfall, 1.2 inches/hr. was recorded. In studying the drainage program we have used this record. As this rainfall is based upon part of the data obtained by the automatic rain gauge, however, it might be necessary to correct the above record by investigating the whole data.

According to the data recently made available to us, therefore, we shall hereunder try to calculate the probability of rainfall. Not only in relation to the rainfall, however, calculation system in this report is an approximation at the present stage. We shall here mention that more preciser calculation system should be resorted to in practice.

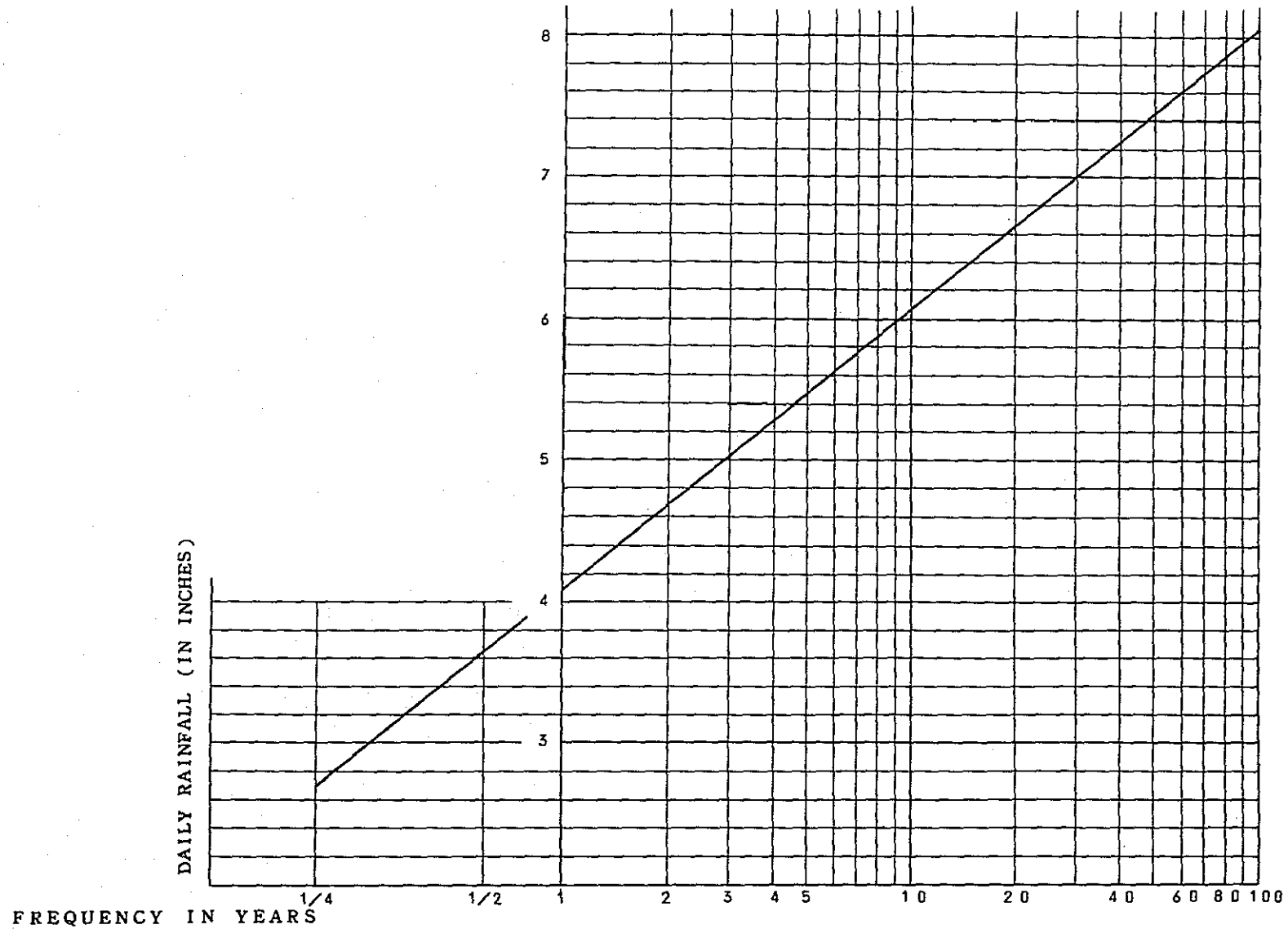
Considering the rainfall observations in the Nariva area for the recent 10 years, average daily rainfall in this area is approx. 4.2 inches according to the isohyetal map. When the probability of daily rainfall in this area was calculated on the basis of the data on Newland Biche, (Observatory No. 62), which seemed to be typical of the stations, where the daily rainfall closer to the above value was measured, the following Table 12 was obtained:

Table 12: Probability of the daily rainfall

Probability	Rainfall
1/1 year	4.2 inch
1/2 "	4.75 "
1/5 "	5.4 "
1/10 "	6.0 "
1/20 "	6.6 "
1/30 "	7.0 "
1/100 "	8.0 "

The above values are illustrated in the Fig. 5.

Fig. 5 Probability of daily rainfall in the Nariva area



2.4 Run off mechanism of the flood

The above rainfall record is naturally important to define the run off mechanism of the flood. But it is dependent upon the topography, geology, river condition, gradient of rivers, etc. Various methods for estimating the run off mechanism have been, therefore, suggested. In order to grasp this run off mechanism exactly, it is important to analyze on the basis of the data on the run off measured when various rivers are flooded.

At present, however, no data necessary for analyzing the run off mechanism in this area is not made available. In this connection, we shall hereunder suggest the data, which would be required in future:

(a) Observation of the rainfall

The present observation shall be continued. In order to analyze the rainfall strength, automatic rain gauge is desirable.

(b) Observation of the sea level

Automatic recording tide gauge is desirable. The tidal curve is important in planning the drainage in the Nariva area affected by tide. Considerable amounts of data on the west coast area are made available. It would be, however, dangerous to use these data, because the information has disclosed that the tide of Cocal bay along the coast of the Nariva area would rise considerably by flow of Orinoco river. It is, therefore, necessary to build an automatic tide-gauge station near the mouth of Nariva river for observing the tidal movement.

(c) Measurement of the discharge of rivers

In order to find the run off mechanism of rivers, data by means of automatic water gauge are desired. In case the obaservation is to be simplified, as there are a large number of small rivers, however, several larger rivers can be chosen, and the analyzed observations can be applied to the other small rivers. As a simpler analyzing method, we suggest a system of recording by means of a water gauge laid on several points of the lowland of the Nariva swamp area. This system is

based upon the assumption that the flood concentrates in several blocs, because the inundation in the area and the flow into the sea would disclose the run off mechanism in the whole area, only when the discharge of Nariva river is observed.

(d) Topographic maps

Topographic maps are naturally required not only for the drainage program but also all other plannings. Especially for the drainage program, topographic maps of approx. 1 ft. contour line space and approx. 1/1,000 ~ 1/2,000 scale each are required.

(e) Survey of the intake (water rights)

It is necessary to survey the present condition of the intake of water supply and irrigation water from the rivers flowing into the Nariva area. In case there is a dam in the river basin, which cuts its discharge, flow section of the drainage canal, plan could be small. In this connection, we have considered it necessary to investigate how much water (ft^3/sec) is discharged from the Navet dam into the Navet river in flood or driest season. In making the irrigation program, too, this would come into question. The utilization of water on the upper course of river would make the drainage easy. But on the other hand, it would make it difficult it to secure the irrigation water. (refer to the item, Irrigation program)

2.5 Policy of the drainage program

As the drainage program greatly affects the cost for construction work, it must be so carefully worked out after checking the perfect data that it may be economically justified. As a fundamental system for developing the swamps in the Nariva area, we have employed a double dike system. According to this system, pool is laid between the farm land and the sea, and utilized as a regulating reservoir, while the present beach bank on the coast is used as the sea dike. We shall hereunder explain our idea of drainage program.

It is a general drainage system that the run off from the area outside of farm land is discharged into the open sea by gravity through the canals (such as the catch drain, and the

drainage canal) as far as possible. It is advisable to employ the above system to reduce the drainage capacity in the area to be developed. We have, therefore, planned a drainage system, in which the gravity drainage is chiefly used, and the pumping out of the area is reduced as much as possible.

Outline of the drainage program for this area is as follows. As previously mentioned, however, it is necessary to investigate our assumed conditions fully in deciding the project finally, because complete data on the drainage have not been made available.

In the first place, basic plan is to build a main drainage canal so that the Navet river, the largest in this area may connect to the mouth of Nariva river, where a sluice and a fixed weir are built to prevent the incoming of sea water and to drain the flooded area.

In case the future survey discloses that only the regulating gate would be not competent to control the water level in the flooded area, pumping station must be additionally laid. As the scale of drainage gate is then interrelated to the pump capacity, the most economical scale should be decided from both viewpoints of the costs for the construction and maintenance. At the stage of our recent approximation, we have assumed that the drainage would be possible, when a regulating gate and a weir are built.

In deciding the regulating gate, meanwhile, there is another factor, which is a regulating reservoir. As the regulating reservoir is laid not only to control the flood but also to irrigate the farm land, its size is also restricted by the irrigation program.

Regulating reservoir shall be laid on the lowest place behind the beach banks along the Cocal bay (which form natural sea dikes), and connected to the drainage canals which drain from other areas.

As this regulating reservoir has two objectives of storing the flood water temporarily and reserving the water for irrigation, its economical acreage should be decided after estimating the change in the water level of regulating reservoir, and studying various aspects of the project collectively.

2.6 Outline of the drainage program

River basin shall be divided into the hill and flat (swamp) districts. At first, the flood in the hill district must be controlled. As for the acreage of hill district, the basin of Navet river shall be excluded from the planned basin. In other words, it is assumed that the Navet dam should store the whole quantity of run off, and not discharge the water into the down stream even at the flood. Therefore, the acreage of drainage area of the hill side district is 65,000 acres.

On the other hand, the acreage of the flat side is 40,000 acres.

2.6.1 Flood

(a) Daily rainfall

The probability rainfall for 100 years shown in the Item 2.3 is used. It is 8 in./day. If this probability is made from a combination of the rainfall intensity and the tide, it would be higher generally. Considering the worst condition, we have employed various factors so that the project may be fully safe.

(b) Rainfall intensity

Rainfall intensity, 1.2 in./hr. shown in the Item 2.3 is used. If the data are put in order, it might be reasonable to use the intensity, higher than 1.2 in./hr. In this connection, rainfall intensity shall be further studied.

(c) Tidal curve

As the practically measured data, only the report submitted in 1957 by the FAO is made available. It is, therefore, necessary to build an observatory and prepare the data. On the basis of the FAO report data, we have assumed an approximate tidal curve.

(d) Flood wave form

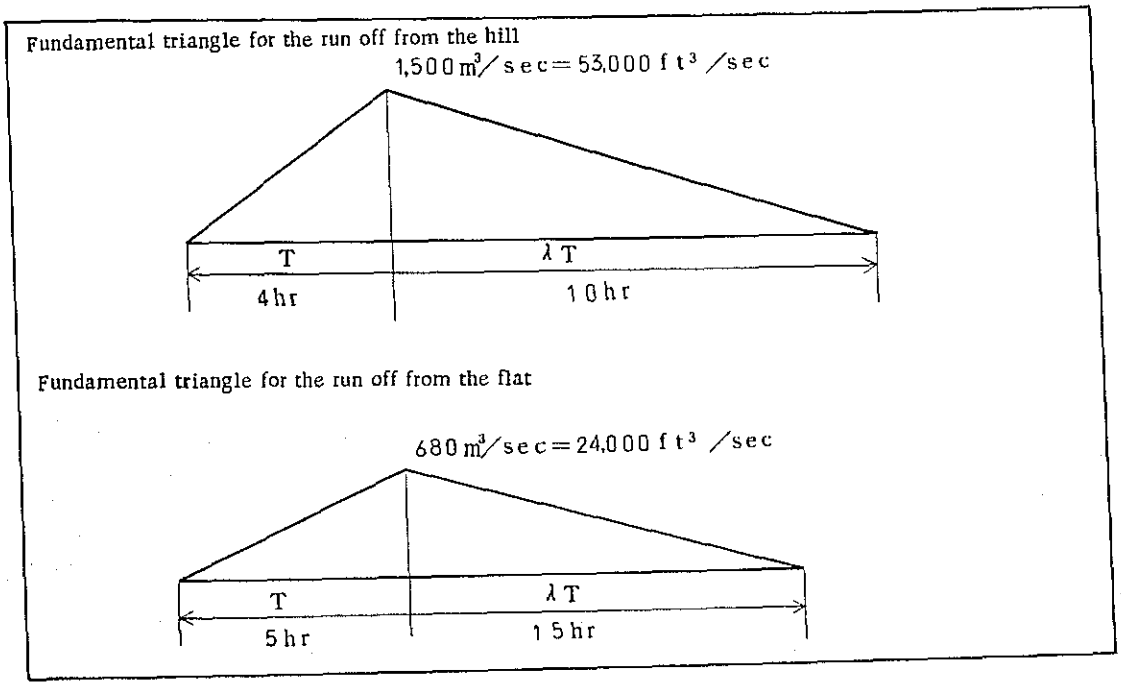
Observation of the run off of rivers, or the analysis by means of practical method in the Item 2.4, is required. As no data is made available at present, we have tried to make a rough estimate by means of estimation formula generally used. (In a project of this kind, the unit hydrograph method based upon

the practically measured data has been generally used.)

The first assumption is that the flood wave form is triangular. The second is that the run off coefficient at the hill side is 70%. The third is that the flood at the hill side reaches the regulating reservoir in four hours, when the flood arrival time is calculated from the Rziha formula. The fourth is that the peak flow is based upon the rational formula.

When the calculation is made on the above assumption, result can be obtained as shown in the Fig. 6.

Fig. 6 Fundamental form of the flood run off



(e) Drainage in the area

We have so planned that the flat side, i.e. the district to be developed may be surrounded by the dikes of drainage canal and regulating reservoir, and that the district may be submerged by closing the regulating gates, when the natural

drainage is impossible (we consider that the farm land surface is almost on the same level as the average tide). Because we have understood that the inundation, approx. 1 ft. about the paddy field would not disturb the rice crop, as it is assumed that the lowland of the development area should be used as the paddy field in rainy season. Even if the planned paddy field, 24, 500 acres is flooded with the planned rainfall, the average submergence depth would be 0.8 ft., and the maximum 1.6 ft. The inundation period is within 1 day. Rice crop in paddy field would not be affected by such a flood. For the safety, therefore, we have planned to build a pumping station, where the irrigation pump can be also used as a drainage pump. It might be, however, necessary to lay a drainage pump to control the underground water.

(f) Calculation method for the regulating reservoir acreage and the drainage

In planning the regulating reservoir, change in the water level for the flood control, control water level required for the irrigation, and other uses as the fishery, etc. must be taken into consideration. In rainy season, the regulating gate shall be so operated that the water level of regulating reservoir may not be as higher than the control level as possible. Drainage calculation shall be made on the basis of the storage capacity of regulating reservoir, tidal curve, and the roughly estimated flood flow. Two kinds of regulating reservoirs, 2, 500 and 5, 000 acres have been imagined. On the other hand, regulating gate of effective width, 650 ft. and a weir of length, 650 ft. have been assumed. It is assumed that the elevation of crest of the weir is 101.20 ft. higher than the max. tidal level, 101.10 ft. based upon the FAO report.

In calculation, we have assumed that the max. tidal level is 101.10 ft., the min. 97.0 ft. and that the tidal curve is a sine curve. Though the min. tidal level is 96.10 ft. according to the FAO report, we have employed the level, 97.0 ft. for the reason of safety. As previously mentioned, therefore, it is the future subject of study to correct the tidal curve on the basis of actually

measured data. In the meantime, we have made a rough calculation in behalf of safety so that the flood peak may agree with the high tidal level.

The control water level relates to the irrigation program hereinafter mentioned. In short, it is a point that the min. water requirement for the farming in dry season should be secured. We have assumed that the control water level of regulating reservoir is 99.0 ft. when its acreage is 2,500 acres, and 98.0 ft. when it is 5,000 acres.

On the other hand, we have assumed that the min. water level of regulating reservoir is 96 ft., when its acreage is 2,500 acres, and 96.5 ft., when it is 5,000 acres. Results of the drainage calculation made on the above assumptions are as shown in the Figs. 7 and 8. We have so calculated that only the convex portion of the present ground may be excavated in building the regulating reservoir, in order to reduce the cost for construction work.

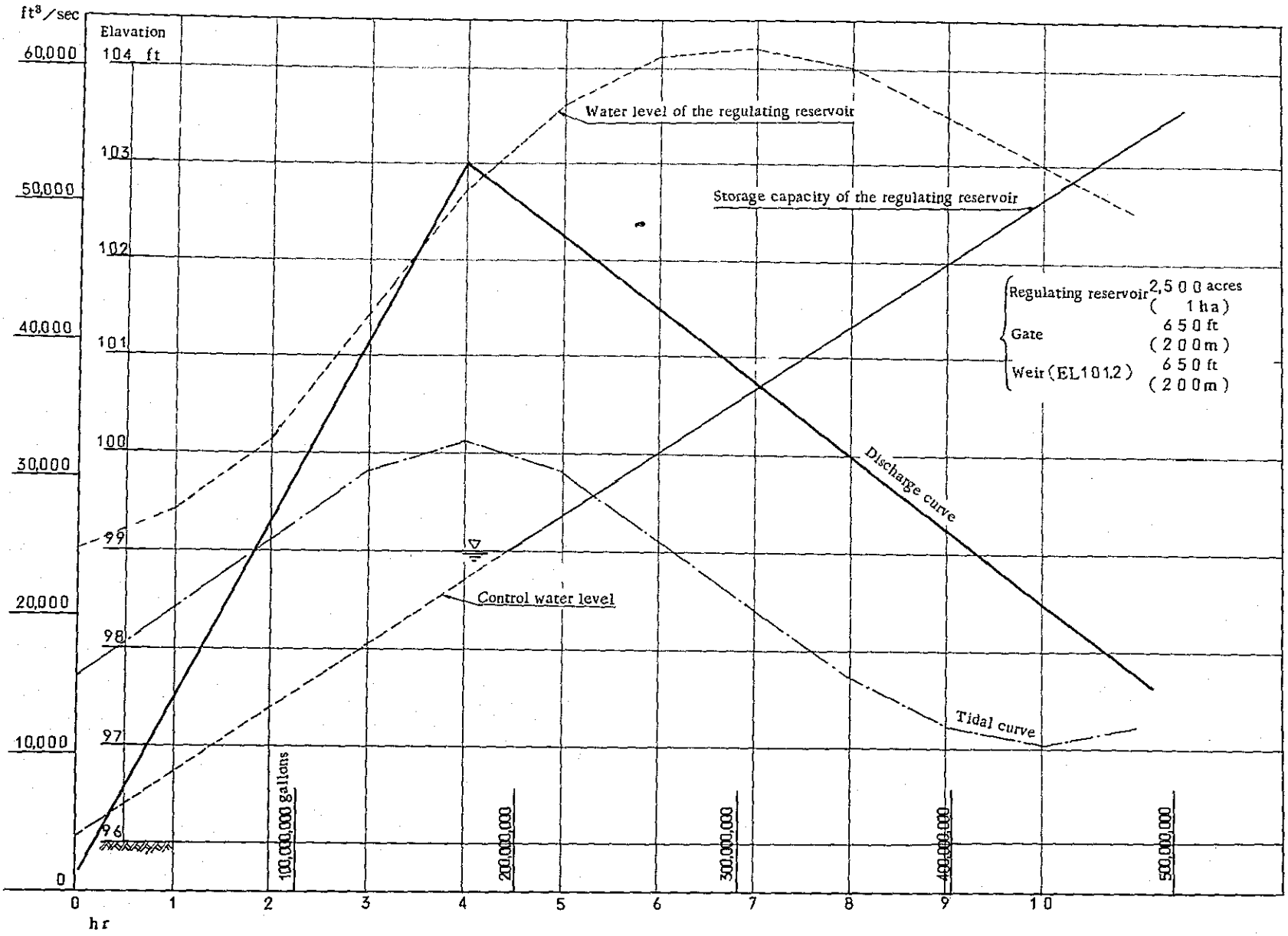


Fig. 7 Calculation of the drainage (when the regulating reservoir is 2,500 acres wide)

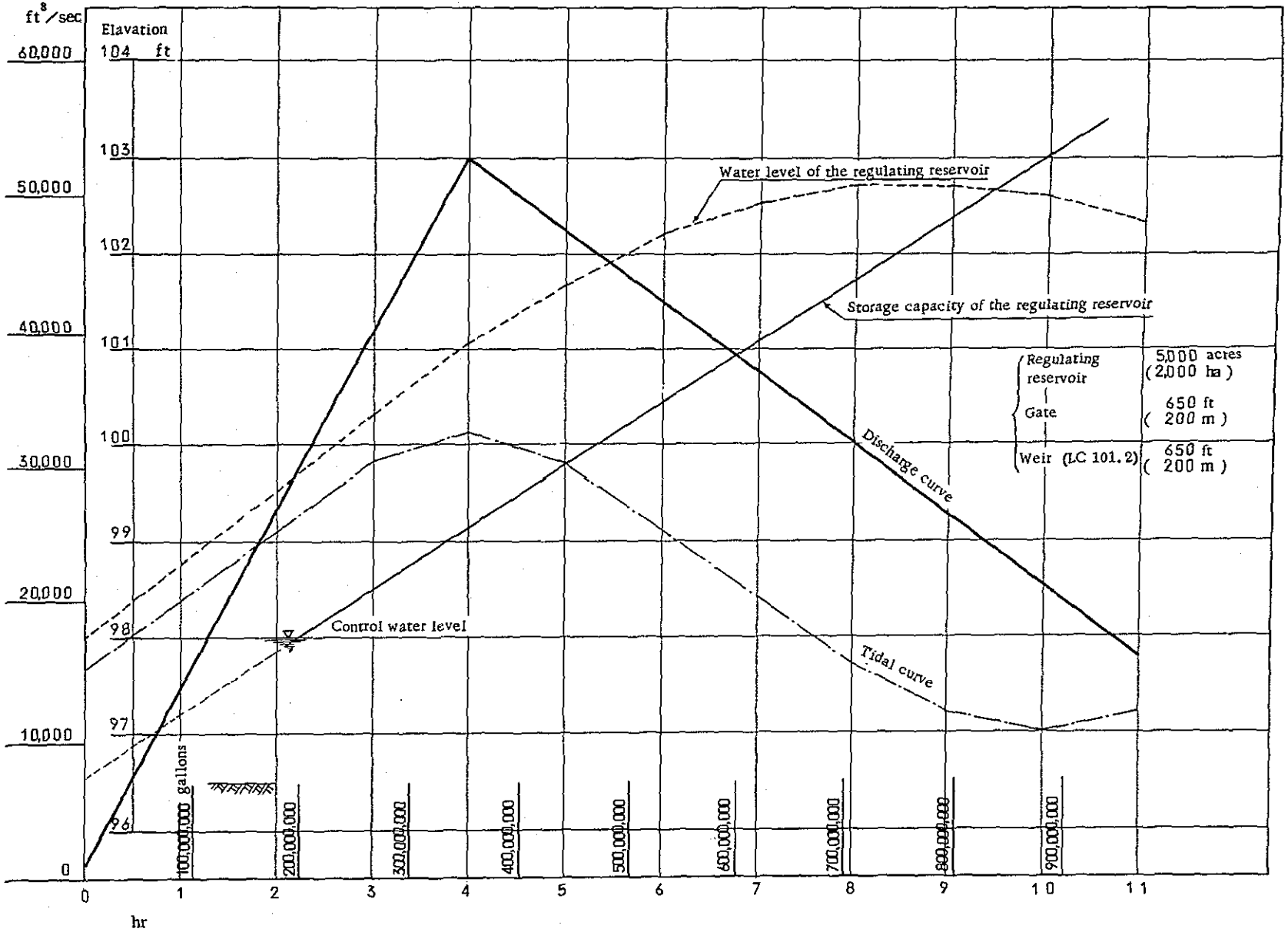
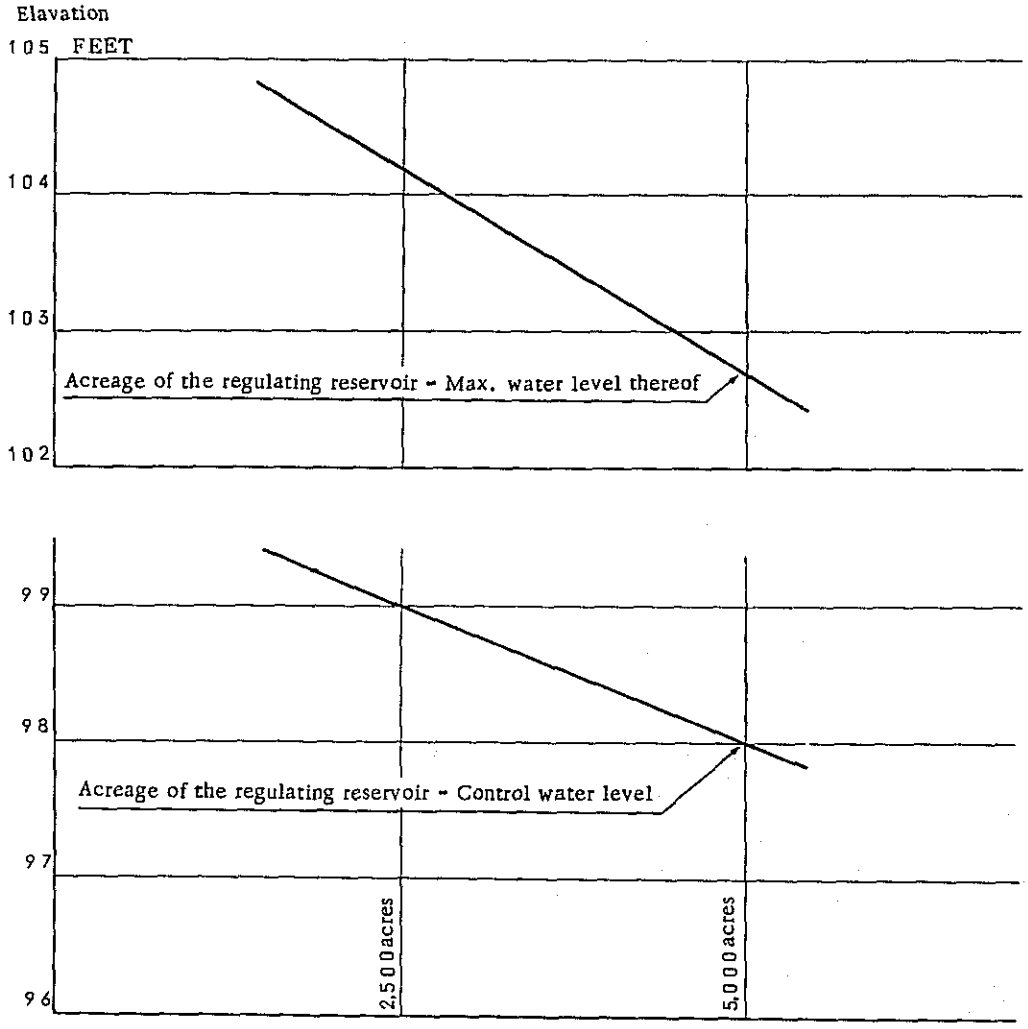


Fig.8 Calculation of the drainage (when the regulating reservoir is 5,000 acres wide)

(g) Drainage calculation results

Interrelation between the water level of the above two sorts of program, and the acreage of regulating reservoir is plotted in the Fig. 9.

Fig. 9 Relation between the regulating reservoir area and water level



Calculation has disclosed that the max. water level is 104.2 ft., when the acreage of regulating reservoir is 2,500 acres, and 102.7 ft., when it is 5,000 acres.

If the acreage of regulating reservoir is larger, the acreage under cultivation would be smaller. If the acreage of regulating reservoir is reduced, however, the water level of regulating reservoir would rise to increase the cost for building the dikes. As there is thus an interrelation between the cost for work and the effect, therefore, it is necessary to study the most economical point. As we cannot make a precise calculation (for lack of topographical maps and hydrologic reference data), we cannot draw a conclusion. But we are sure that it would be more advantageous, if the acreage of regulating reservoir is approx. 5,000 acres or more than that. At this trial stage, meanwhile, no pumping-out is considered.

2.6.2 The river mouth

The mouth of the Nariva river seems to have been balanced and maintained by the outflow of river and the tidal change. As our planned drainage system would break the above balance, the river mouth would be blocked or moved.

In working out the program, it would be necessary to make a survey of tidal movement, drift sand, the movement of sand bar, etc., and, if possible, decide the maintenance method for the river mouth by means of model test. If this method is mistaken, the present beach line could not be maintained.

At the present stage, when we cannot obtain any fundamental data, we cannot suggest any concrete method, which we should like to study in future. On the other hand, maintenance and control of the river mouth after the completion of the work would be also important.

3. Irrigation program

As mentioned in the item, drainage, the ratio of the developed district to the rest basin

district is very small. Even when the program is favorable to the drainage, however, it becomes unfavorable for want of water, when it is considered from a viewpoint of irrigation. In addition, this area is characterized by the bad condition that the some part of water is used as the supply water to other areas by means of the Navet dam on the upper stream of the river.

As for the characteristic of the rainfall in this area, meanwhile, there are two seasons: dry and rainy. Average monthly rainfall in dry season is approx. 4.0 in., while that in rainy season approx. 10 in. It is, therefore, necessary to consider how to secure the irrigation water in dry season.

In this connection, the following three plans would be possible:

(1) Plan for building a dam with reservoir (on the upper stream of the river)

(2) Plan for taking the water from other area

(3) Plan for utilizing the regulating reservoir for the flood control

The above three systems shall be studied hereunder.

3.1 Dam building plan

This plan must be studied in relation to the Navet dam previously mentioned. It must be then considered that the water for the water supply and agricultural use should be stored. According to our experience, the following defects of dam plan are considered:

(1) No suitable site for building the dam is found.

(2) Even if the water is led from other areas, and stored, no favorable basin cannot be found in the neighborhood.

(3) For the reason of the basin acreage of the dams, dams cannot be built for the water supply and agricultural uses respectively. Dam must store the water for both uses.

(4) Dam cannot topographically store the rainfall of the whole basins.

Even if this dam plan is enforced, the cost for construction work would be increased, and the dam could not become an economical water source.

3.2 Plan for taking the water from other area

In planning a plan for the intake from other area, it would be necessary to survey the Ortoire river flowing in the adjacent Mayaro district. Though an exact judgement is difficult, as no data on this river is not made available, to intake water by gravity would be impossible so long as our observations are concerned.

There would be, therefore, no alternative but to lay a pumping station for the water intake. On the other hand, it is questionable that the whole required water is taken from this river. It is accordingly necessary to survey the districts irrigated by this river, check whether the river is used as a source of the supply water, or not, and define the relation with the droughty water discharge of this river. Even if this system is employed, it would be impossible at the present stage to build an irrigation canal exclusively used for dry season to the irrigated district of the Nariva area. But a plan for pumping this river into the regulating reservoir in dry season would be worthy of further investigation.

3.3 Plan for utilizing the regulating reservoir

Fault in the plan for utilizing the regulating reservoir is that part of the district must be pumped up for the irrigation, as the reservoir is built on the lowland. If the irrigation pump can be also used for the drainage at the flood as mentioned in the Item 2.4, however, the above fault could be more or less covered.

Advantages of this plan are as follows:

Water can be repeatedly used, when the shortage of water is made up as in this district, because this system controls the rain and underground water in the whole basin. As the drainage facility is utilized, meanwhile, the influx of sea water can be controlled to secure the quality of irrigation water, when the regulating reservoir is built in the hinterland of beach bank. It is unnecessary to build any facility exclusively used for the irrigation. From the collective viewpoint, therefore, we think that this plan is an economically favorable plan.

3.4 Water requirement

In deciding the unit water requirement, it is necessary to survey the effective

evaporation, transpiration and infiltration of water, and study the irrigation efficiency. In addition, the cropping system relates to the irrigation system.

There are few actually measured values to decide the unit water requirement. At the present stage, therefore, we have calculated the average daily water requirement in depth for the paddy rice crop on the basis of the values of FAO report and the values practically observed in our recent survey as follows:

Table 13: Monthly water requirement

Evaporation per day;	0.15 inch			
Water requirement;				
Monthly	Jul.	Aug.	Sept.	Oct.
	6.9 inch	7.0	6.6	6.7
Daily	0.22	0.22	0.22	0.21

Accordingly, average water requirement in depth per day is 0.22 inch. When we measured the water requirement in depth for 24 hr. on the paddy field of Plum-Mitan area, it was 0.39 inch. Considering the above results, we have estimated that the whole water requirement inclusive of the canal loss is 0.4 inch per day.

On the other hand, there is no material from which the water requirement for the upland irrigation is estimated. From our experience, however, we have trially estimated the irrigation water requirement for 10 days irrigation interval at 1.2 inches.

3.5 Number of continuous drought days

Number of the continuous droughty days for the recent 10 years obtained from the data upon the rainfall in the Biche district is as shown in the Fig. 10.

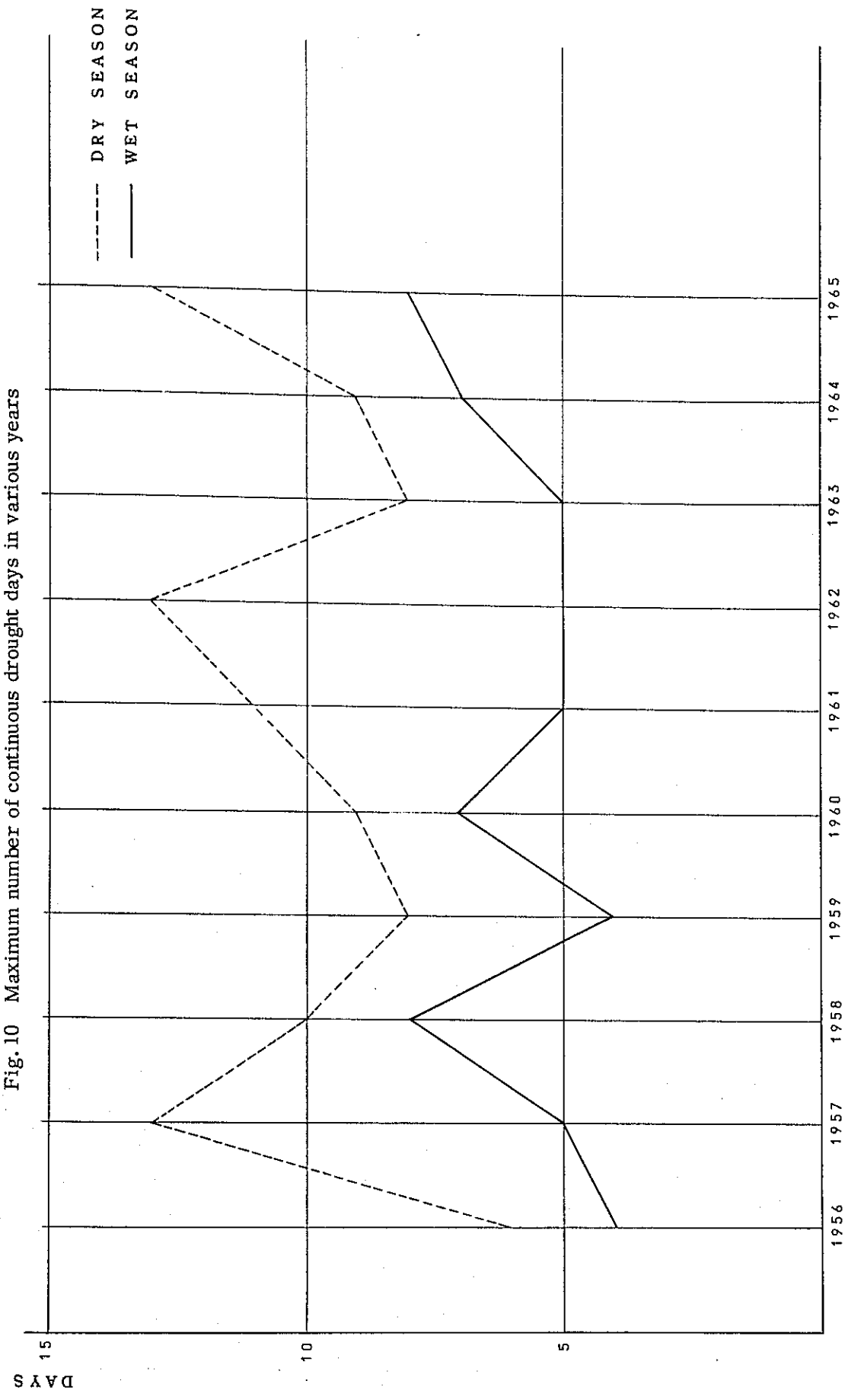


Fig. 10 Maximum number of continuous drought days in various years

3.6 Storage capacity and the control water level of the regulating reservoir

On the basis of the above, control water level of the regulating reservoir shall be decided. If the number of continuous droughty days is 9, and the irrigation water is supplied for 9 days, the water requirement for the rice crop in the paddy field, 24, 500 acres in rainy season could be approx. 1, 980, 000, 000 gallons. In relation to the irrigation for the upland crops in dry season, meanwhile, it has been assumed that the rainfall is small, evaporation is considerable, and the irrigation is given, when the drought is 30 days long. This irrigation would amount to 1, 980, 000, 000 gallons. We have made the control water storage capacity of regulating reservoir of the above amount. As previously mentioned, the regulating reservoir has an advantage that the reduced flow can be repeatedly utilized. If it is repeatedly utilized, the number of droughty days could be increased. In order to decide the capacity and the control water level of regulating reservoir, standard year of the irrigation program shall be decided, and such a close calculation mentioned above shall be made.

Figures shown in this report are the approximate values. As for the irrigation of the area, 7, 500 acres to be utilized as grassland, it has been excluded from the calculation, because the excessive water may used.

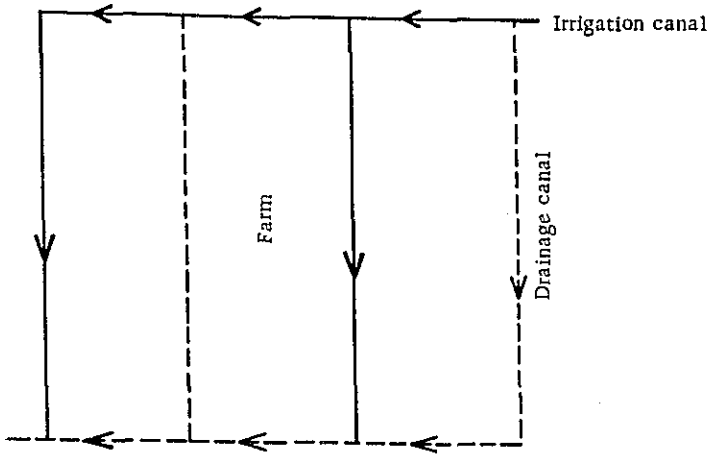
In the above calculation, it has been decided that the water level of regulating reservoir to secure the water, approx. 1, 980, 000, 000 gallons is a control water capacity. In case of calculating the drainage, therefore, this control water level has been a starting point of the calculation (refer to the item, Drainage).

3.7 Land development

In working out the development program for farms, we have chiefly considered the rice crop. We have employed a system of separating the irrigation canal from the drainage canal fundamentally. In other words, it is a general farm program on the lowland that the irrigation canal is laid side by side with the drainage canal alternatively.

The size of divided pilot is dependent upon the cropping pattern, sort and size of tillers to be used, and the work of underdrainage. In order to show the location of canals, a

model is shown hereunder:



The need of underdrainage should be decided by the future close soil survey including the check of the depth, interval, etc. of the required drainage.

4. Road, village and facility program

After the decision of the location of village, network of the roads connecting the farms with one another at the shortest distance is desirable. But it is also restricted by the plotting of farms and the location of irrigation canals. The location of village, which we have considered, is a site secure against the abnormal inundation. In this connection, it would be advisable to choose such highland of firm ground as the forest area a little higher than the submerged flat, e.g. Sandhill, Bush-bush, Bon Neuf and the high district at the foot of hills. As for the road connecting the village with the farms, road for the maintenance of channel should be utilized as far as possible, because the conservation road is indispensable to the canal, and can be economically built as the dike of water canal by means of the soil of excavated canal.

As for the construction of this road, it would be enough to build a simple pavement, in which crushed stone is mixed into the roadbed as practiced in this country, natural pitch is scattered and rolled thereon.

In the center area of the village, rice center (rice-polishing mill, storehouse, etc.) shall be laid. This center shall be competent to treat the rice produced in the whole districts, and be utilized jointly.

5. Working program

The greater part of the Nariva area is made of clay ground. Some hills are made of sandy soil. In executing the construction work, construction equipment should be used for the following reason:

(1) As this area is a swamp zone, construction work is generally restrict. Especially in rainy season, working by manual labour is difficult.

(2) It is necessary to reduce the construction period, and obtain the effect immediately.

Above all, the excavation of drainage canals and regulating reservoir would be more considerable amount of earthmoving. We have, therefore, suggested that the work should be chiefly conducted by medium-sized Diesel pump dredgers, which could be also used for the maintenance and conservance of canals, because the banking of dike, by carrying and scattering the excavated soil in the area, and the reclamation of lowland in the area can be economically conducted, when the dredgers are used for the earth-moving.

When the land construction equipments are used for working the weak ground, bearing power of the ground supporting the machines comes into question. When the dredgers are used, however, bearing force of the ground does not matter.

In working the other portion, land construction machines shall be used. In this case, too, the above-mentioned bearing force of the ground comes into question. From our observations, and the fact that the dragline is active in some area (Plan-Mitan area) even during the unfavorable period in rainy season, it is conceivable that the construction work is possible, when the mat is used.

It is, therefore, advisable to make a soil mechanical survey of the whole area, and subsequently divide the area into two portions: one portion where land construction equipment shall be used, and the other where the dredgers shall be used. It would be then a safe working method to employ the above two systems jointly.

6. Cost of the construction works

In this area, partial development is possible. In other words, the higher district, which

is easily drained, could be first developed stepwise. In case of the partial development, however, drainage canal, regulating water gate, etc. should be worked on a final project scale, because excessive cost would be required, if the work partially developed is remodelled into the work on a final scale. But the propriety of partial development should be judged on the basis of its scale and stage of the work.

We shall hereunder roughly estimate the cost necessary for the development of the whole areage of the area:

Regulating reservoir (including the dike)	10 mile	×	1, 000, 000 =	10, 000, 000 TT$
Main drainage canal (")	2.5 mile	×	700, 000 =	1, 750, 000
Branch drainage canal (")	35 mile	×	300, 000 =	10, 500, 000
Roads	90 mile	×	45, 000 =	4, 050, 000
Land development (including the irrigation system)	24, 500 acre	×	1, 000 =	24, 500, 000
Grassland development	7, 500 acre	×	400 =	3, 000, 000
Irrigation and drainage pump in the development area				400, 000
Regulating gate and weir				1, 800, 000
Mouth treatment, cost of the design and others				400, 000
Total				56, 400, 000

The above cost of the construction work is a total of only the expenses for developing the farm land excluding the costs of the construction of houses, etc. in the village district, experiment farms, the rice center, and others.

CHAPTER Ⅳ ECONOMIC VALUATION

Chapter IV Economic valuation

In order to measure the economic feasibility of the investiment, such a medium as the benefit-cost ratio has so far been often used.

In recent days, meanwhile, the internal rate of return seems to have been often used. In this report, however, we have tried to analyze in terms of the benefit-cost ratio. In this report, we have assumed the period of analysis and the rate of interest as follows:

(1) Period of analysis

It shall be 50 years, the same as the economic life in the project.

(2) Rate of interest

Analysis shall be given in relation to the rate of 6% and 3% as follows:

6% : Standard rate of interest for the international financial organs

3% : Rate of interest in case of the soft money

1. Benefit

As mentioned in the above Chapter III, 1, the land utilization program for the Nariva area is as follows:

Total acreage of the area	40, 000 acres
Acreage under cultivation (paddy field in rainy season)	24, 500 acres
Acreage of the grassland	7, 500 acres
Acreage of roads, canals, village, etc.	8, 000 acres

When the benefit is calculated in reference to farmer management types, (a) and (b) according to the above land utilization program, the followings are obtained:

(a) In case of a farmer who crops the rice, soybean and breeds the beef cows

When it is calculated in terms of the new profit rate mentioned in the Chapt. III, benefit amount per acre is as follows:

Rice:	TT$390 × 0.39 = TT$156	TT$188
Soybean:	TT$100 × 0.32 = TT$ 32	
Beef cows:	TT$214 × 0.3 =	TT$ 42.8

Benefit amount in the whole area

TT$188 × 24,500 acres =	TT$4,606,000
TT$ 42.8 × 7,500 acres =	TT$ 321,000
Total	TT$4,927,000

(b) In case of a farmer who crops the paddy rice and corn, and breeds the beef cows

Benefit amount per acre:

Rice:	TT$390 × 0.39 = TT$156	TT$177
Corn:	TT$100 × 0.21 = TT$ 21	
Beef cows:	TT$214 × 0.3 =	TT$ 42.8

Benefit amount in the whole area

TT$177 × 24,500 acres =	TT$4,336,000
TT$42.8 × 7,500 acres =	TT$ 321,000
Total	TT$4,657,000

As disclosed in the above, the (a) is a little larger than the (b) in benefit. As there are many assumed elements, we have taken the mean in the recent analysis. The mean benefit amount is TT$4,792,000.

2. Annual cost

2.1 Equivalent cost

Total investment cost is converted into the annual equivalent cost as follows:

In case of the interest is 6%;

$$56,400 \times 10^{3}\text{TT\$} \times 0.06344^{*} = \text{TT\$}\ 3,578,016$$

In case of the interest is 3%;

$$56,400 \times 10^{3}\text{TT\$} \times 0.03887^{*} = \text{TT\$}2,192,832$$

(Note) * Conversion coefficient is a yearly capital recovery factor, i.e.

$$\frac{i(1+i)^N}{(1+i)^N - 1}$$

2.2 Annual operation and maintenance cost

It is estimated at TT$14 per acre, therefore,

TT$14 × 32, 000 acres = TT$448, 000 ≒ TT$450, 000

2.3 Annual total cost

In case of the interest is 6%;

TT$3, 578, 016 + TT$450, 000 = TT$4, 028, 016

In case of the interest is 3%;

TT$2, 192, 832 + TT$450, 000 = TT$2, 642, 832

3. Benefit-cost ratio

In case of 6%;

$$\frac{4,792,000}{4,028,016} = 1.19$$

In case of 3%;

$$\frac{4,792,000}{2,642,832} = 1.81$$

4. Problematic points

In the economic analysis, all costs must be compared with all benefits. As the data are restricted, we could make only a very rough estimate in this report.

4.1 Costs

Annual cost does not include the costs for building the village, appurtenant facilities, agricultural product treating mills, experiment farms for demonstration and extension, etc., and the construction interests during the construction work period. These costs must, needless to say, be estimated.

4.2 Benefits

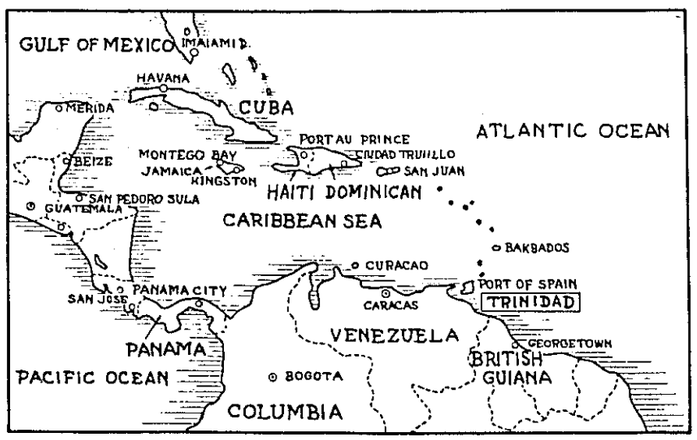
Various benefits of the project are possible. They are tangible benefits which can be expressed in monetary value, intangible benefits which are valuable, but cannot be expressed in monetary value, primary benefits which are brought directly, or secondary benefits which are brought about indirectly.

In our recent study, we have assumed only primary tangible benefits in case of the simplest crop pattern. In practice, however, farmers would make efforts to introduce the most valuable crop, which would have indirectly a large incentive effect upon the market. In the meantime, the establishment of no less than several thousands of new farmers would also have a large social effect.

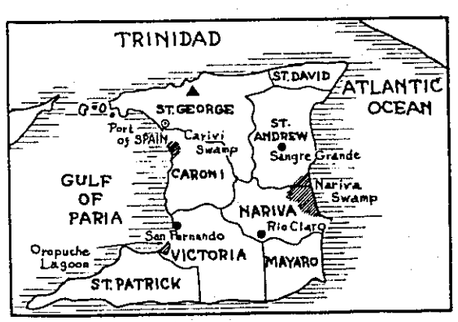
In addition, when the little exploited waste and swamp area are developed into the farms pastures, value of sightseeing industry is also expected. Thus various benefits given to the society and economy of the whole country should be also valued as much as possible.

ATTACHED MAPS

ATTACHED MAP 1. DRAINAGE BASIN OF THE NARIVA AREA

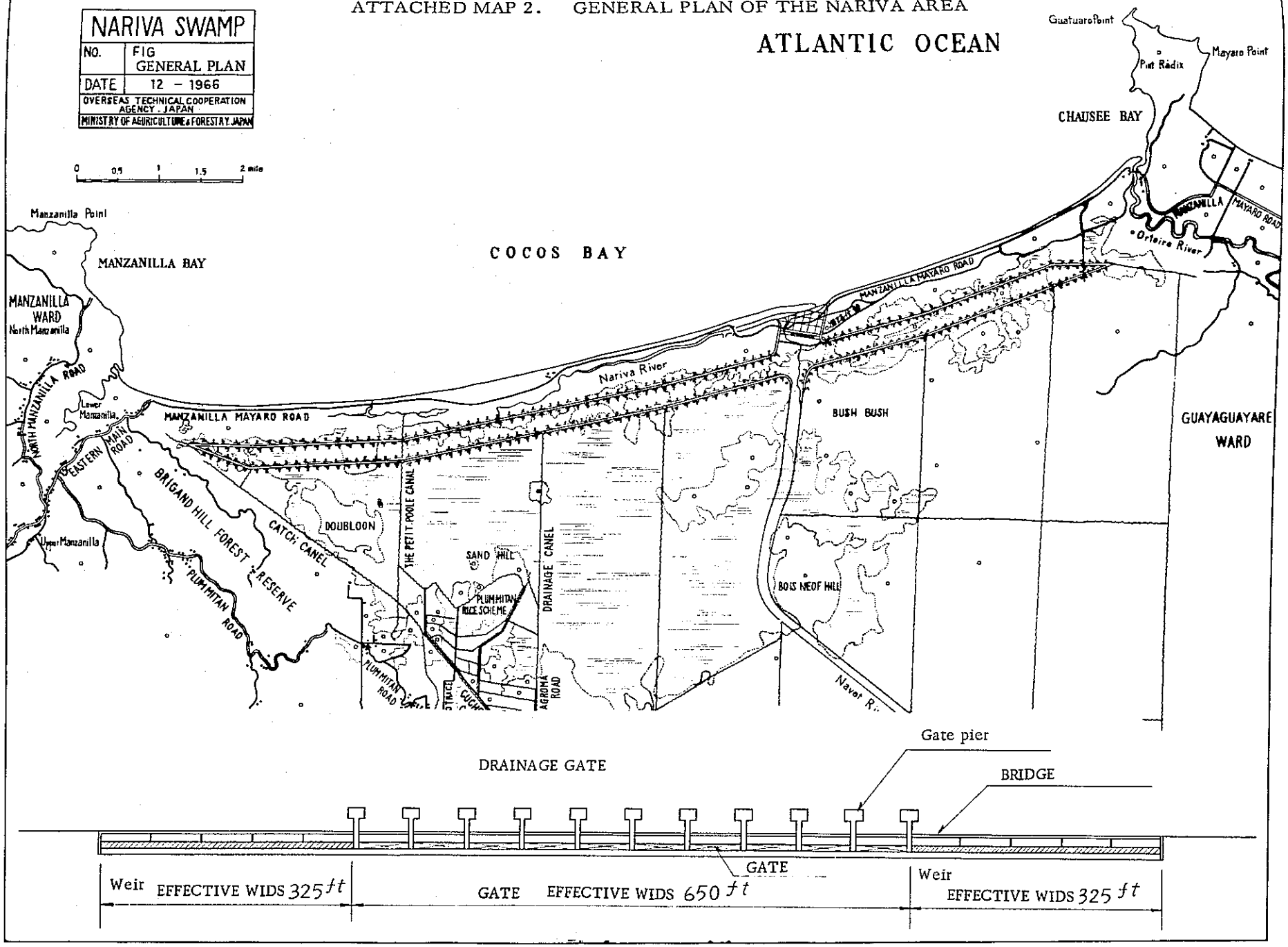


NARIVA AREA.



ATTACHED MAP 2. GENERAL PLAN OF THE NARIVA AREA

NARIVA SWAMP	
NO.	FIG GENERAL PLAN
DATE	12 – 1966
OVERSEAS TECHNICAL COOPERATION AGENCY JAPAN	
MINISTRY OF AGRICULTURE & FORESTRY, JAPAN	



LIST OF THE COLLECTED DATA

List of Collected Information and Data

1. Data

1. The soil of Central Trinidad, Soil Chemist, Department of Agriculture, Trinidad, British West Indies.
2. Annual Statistical Digest 1961-1963.
3. Trinidad and Tobago Year Book 1965-1966.
4. Qvarterly Economic Report 1966.
5. Trinidad and Tobago today. A graphic presentation of Social and Economic Statistics Number 1.
6. Trinidad and Tobago Directory of Industries 1966.
7. Draft Second Five Year Pran 1964-1968.
8. An Economic investigation in small scale Dialy Farming in Trinidad.
9. Journal of the Agricultural Society of Trinidad and Tobago 1965.
10. Ordinance and Rules of the Agricultural Society of Trinidad & Tobago 1933.
11. Serving Agriculture since 1839. Independence Souvenir 1963.
12. Texaco in Agriculture.
13. Irish Potato growing in Trinidad.
14. Notes on Vegetables growing in Trinidad & Tobago-Dept of Agri. Bulletin No. 7
15. A Survey of the Rice industry 1953.
16. Caribbean Market Survey Rice No. 1 1955.
17. Land Utilization Agriculture Production 1956.

2. Hydrology

1. Daily Rainfall

(1)	Cocal	1956 - 1965
(2)	Maridale Estate	1956 - 1965
(3)	Mayaro Police Station	1956 - 1964
(4)	Navet Pris school	1956 - 1965
(5)	Poole Syndicate	1956 - 1965
(6)	New Lands Estate Biche	1956 - 1965
(7)	Bush Bush Camp	1961 - 1965
(8)	Marren Farm Manzanilla	1956 - 1965
(9)	Plam Mitan Rice Sheme	1956 - 1965

2. Photocopy of Automatic Record.

3. Average Monthly Rainfall (32 Rain Gage Stations)

4. Tide Tables (Port of Spain) 1966
   Tide Tables 1967

5. Navet Dam Plan (Hydrology)

3. Power Suply.

1. Wiring for Light and Power - Trinidad & Tobago Electricity Commission 2nd Edition - 1966.

2. Large Load - Trinidad & Tobago Electricity Commission.

3. Off Peark.

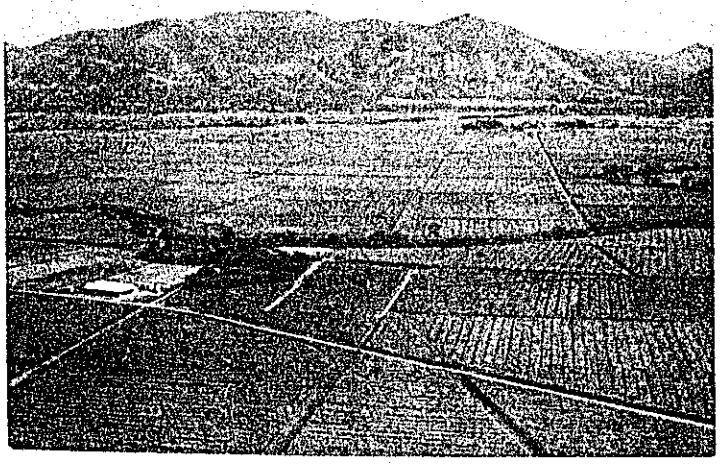
4. Topography.

1.	Nariva Swamp	Showing Eastern Extremity from Manzanilla to Ortoire River Date June 1945 - Scale 12 chains to 1 inch.
2.	Nariva Swamp	Showing levels through Forest Reserve. Date June 1945-Scale 12 Chains to 1 inch.
3.	Nariva Area	Date 2nd March 1955 Scale 1/50, 000
4.	Nariva Swamp	Contour Plan - South East Portion Date 27.3.45 - Scale 1:15, 000
5.	Nariva Swamp	Date? Scale 1:50, 000 DWG No. 112
6.	Tamana	Scale 1:62, 500
7.	Nariva Swamp Rice Production Scheme for Plum-Biche	Date 15th September 1952 Scale 12 cheins to 1 inch.
8.	Nariva Swamp Area	Depertment of Works & Hydraulics Date April 1st 1955 - Scale 1/50, 000
9.	Map of Trinidad Showing Water Areas and estimated Dialy Water requirement in 1968	
10.	Island of Trinidad Scale 1: 175, 000	
11.	Aero Photograph (Nariva Swamp Area)	
12.	ISOHYETAL MAP TRINIDAD	

5. Geography and Soil

Geological Map of Trinidad	Scale 1 : 150, 000
Geological Map of Trinidad	Scale 1 : 100, 000
Soil Map	Scale 1 : 50, 000

PHOTOGRAPHS



Sugar cane farm

Cocoa tree

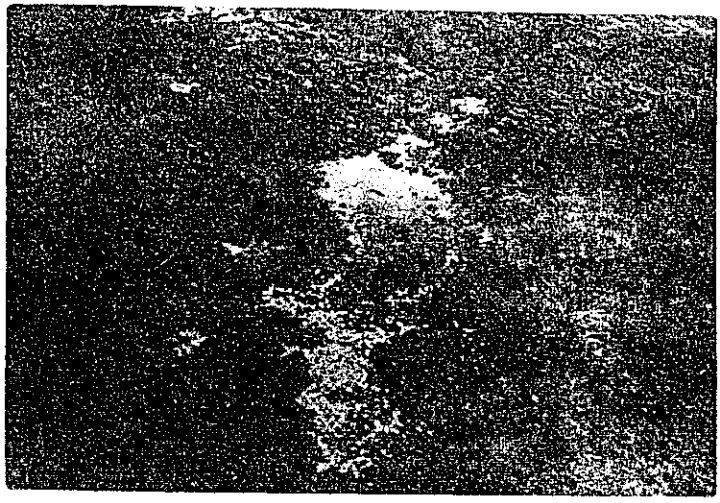
Coconut farm (Beach bank)

Navet Reservoir

Area near BOIS NEUF (middle section)

Cultivated ground near Plum Mitan Road

Cultivated area near Cascadoux



Nariva Swamp (plain and the water surface)

Area near the mouth of Nariva river

Nariva River (Downstream)

Swamp near The Sand Hill

Condition of the hinterland of Nariva river
near its mouth (Road to the Bush - bush)