REPUBLIC OF COSTA RICA
SERVICIO NACIONAL DE AGUAS SUBTERRANEAS
RIEGO Y AVENAMIENTO (SENARA)

# LIMON INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

# (THE MASTER PLAN STUDY)

## VOLUME I

## MAIN REPORT

OCTOBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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SERVICIO NACIONAL DE AGUAS SUBTERRANEAS
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# PREFACE

In response to the request of the Government of the Republic of Costa Rica, the Japanese Government decided to conduct a survey on the Limon Integrated Agricultural Development Project and entrusted the survey to the Japan International Cooperation Agency (JICA). JICA sent to Costa Rica a survey team headed by Mr. Yasuo Maeda, Naigai Engineering Co., Ltd., from February 1987 to March 1988.

The team exchanged views with the officials concerned of the Government of Costa Rica. After the team returned to Japan, further studies were made and the present report has been prepared.

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

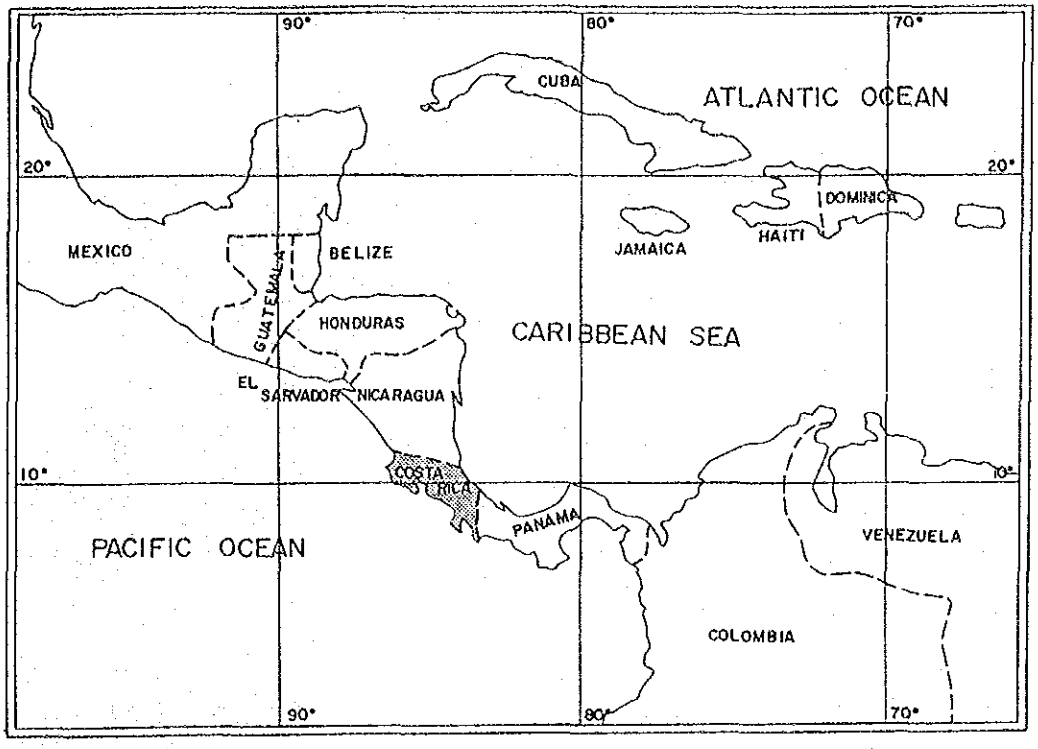
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Costa Rica for their close cooperation extended to the team.

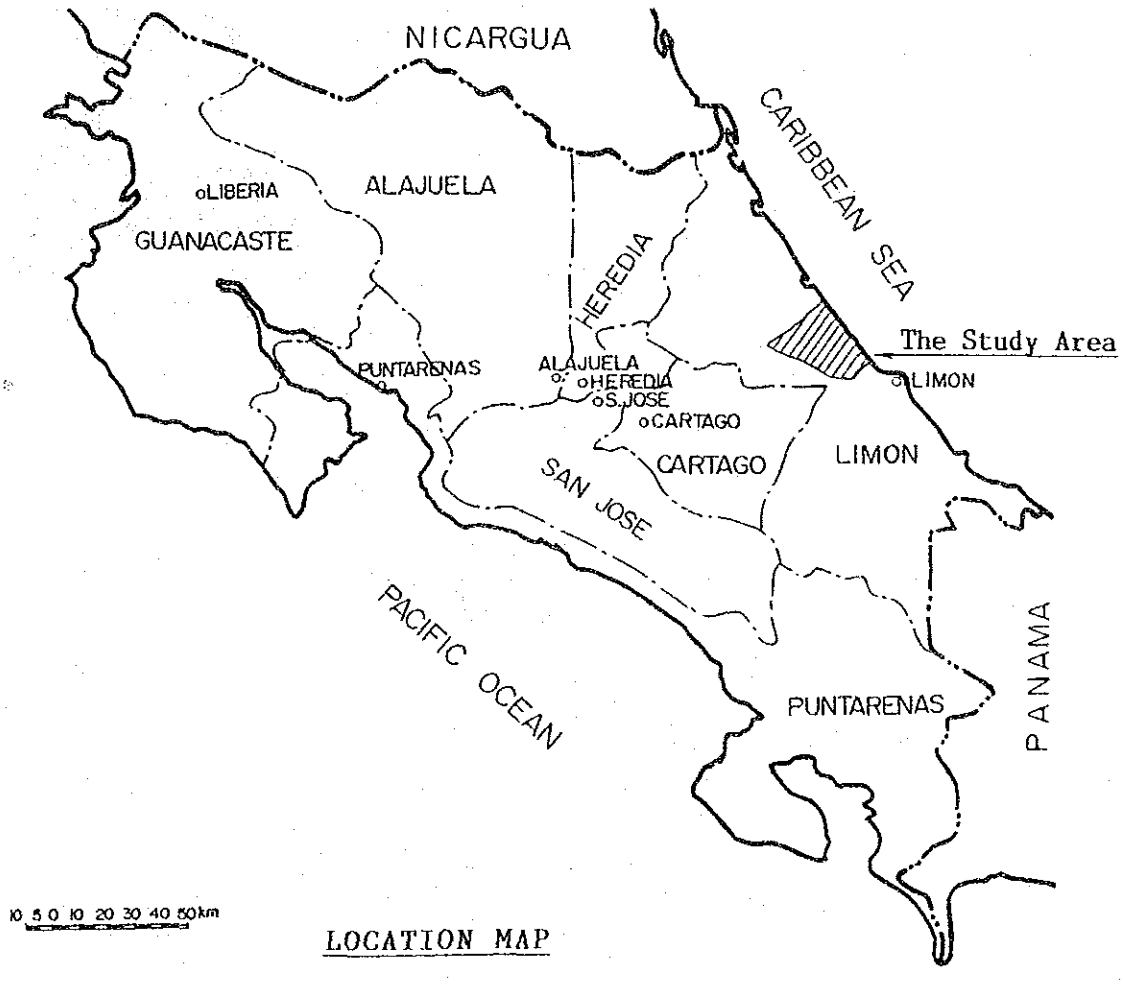
October 1988

Kensuke Yanagiya

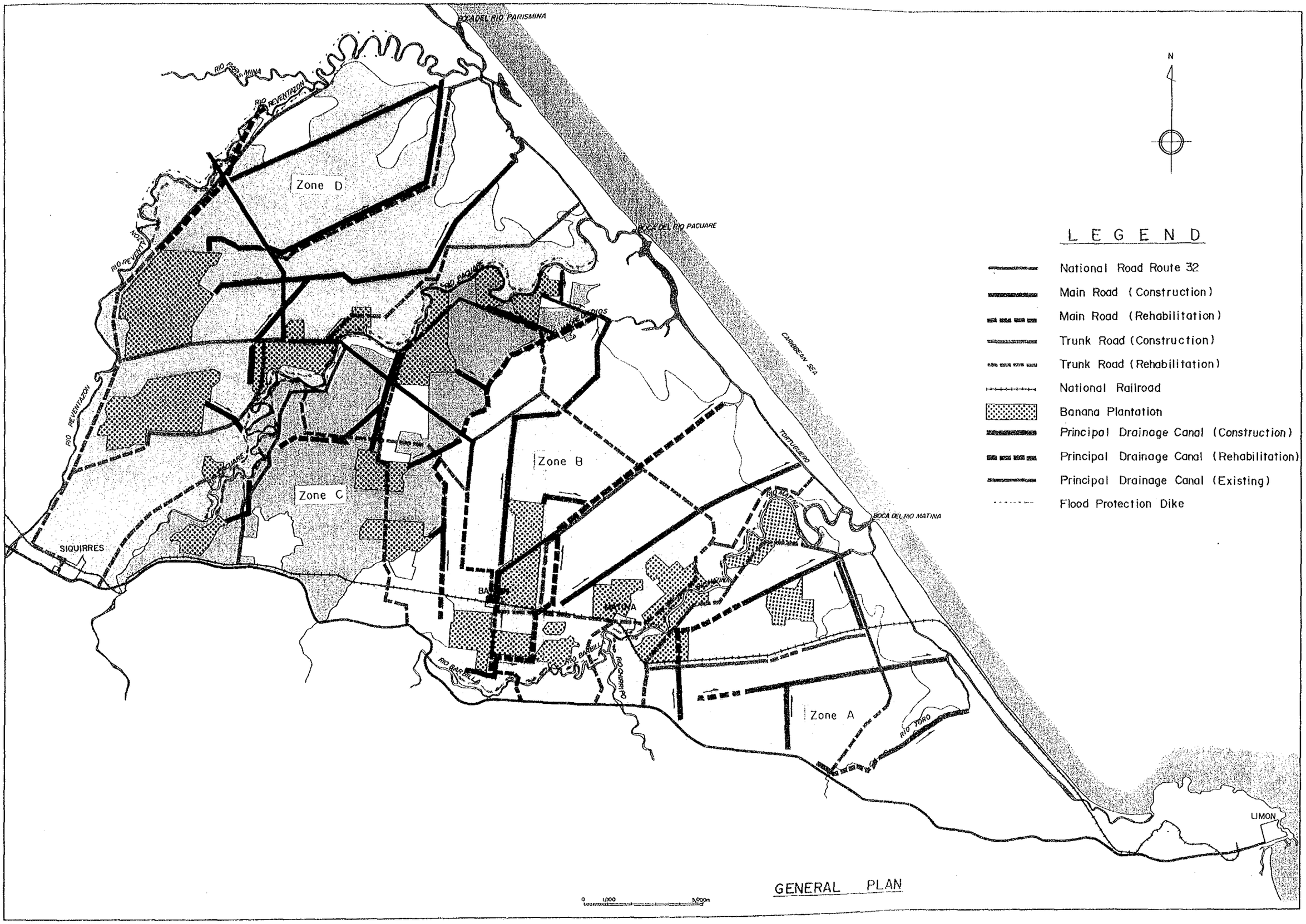
President

Japan International Cooperation Agency




LOCATION MAP

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## LEGEND

- National Road Route 32
- Main Road (Construction)
- Main Road (Rehabilitation)
- Trunk Road (Construction)
- Trunk Road (Rehabilitation)
- National Railroad
- Banana Plantation
- Principal Drainage Canal (Construction)
- Principal Drainage Canal (Rehabilitation)
- Principal Drainage Canal (Existing)
- Flood Protection Dike

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# ABBREVIATIONS

## Institutions and Organization

| | | |
|---|---|---|
| ASBANA | Asociacion Bananera Nacional | National Banana Association |
| BAC | Banco Anglo Costarricense | Anglo Bank of Costa Rican |
| BCAC | Banco Credito Agricola de Cartago | Agricultural Credit Bank of Cartago |
| BCCR | Banco Central de Costa Rica | Central Bank of Costa Rica |
| BCR | Banco de Costa Rica | Bank of Costa Rica |
| BID | Banco Interamericano de Desarrollo | Interamerican Development Bank |
| CATIE | Centro Agronomico Tropical de Investigacion y Ensenanza | Investigation and Education Center for Tropical Agriculture |
| CNP | Consejo Nacional de Produccion | National Production Council |
| FAO | Organizacion de las Naciones Unidas Para la Agricultura y la Alimentacion | Food Agriculture Organization of the United Nation |
| ICCA | Instituo Costarricense de Acuaductos y Alcantarillados | Water Supply and Sewerage Institute of Costa Rica |
| ICE | Instituto Costarricense de Electricidad | Electric Institute of Costa Rica |
| IDA | Instituto de Desarrollo Agrario | Agrarian Development Institute |
| INFOCOOP | Instituto Nacional de Fomento Cooperativos | National Cooperative Fomentation Institute |
| INS | Instituo Nacional de Seguros | National Insurance Institute |
| JAPDEVA | Junta de Administracion Portuaria Desarrollo Economico de la Vertiente Atlantica | Board for Administration of Ports and Development of the Atlantic Basin |
| MAG | Ministerio de Agricultura y Ganaderia | Ministry of Agriculture and Livestock |
| MIDEPLAN | Ministerio de Planificacion Nacional y Politica Economica | Ministry of National Planning and Economic Policy |

| | | |
|---|---|---|
| MOPT | Ministerio de Obras Publicas y Transportes | Ministry of Public Construction and Transport |
| SENARA | Servicio Nacional de Aguas Subterraneas, Riego y Avenamiento | National Groun Water, Irrigation and Drainage Service |

Monetary Unit

| | | |
|---|---|---|
| ¢ | Colon Costarricense | Costa Rican Colon |
| US $ | Dolar Americano | United States Dollar |

Economic Term

| | | |
|---|---|---|
| B/C | Razon Entre Beneficio y Costo | Benefit-Cost Ratio |
| CIF | Costo de Segro y Flete | Cost, Insurance and Freight |
| EIRR | Tasa Interna Economica de Retorno | Economic Internal Rate of Return |
| ENPV | Valor Economico Actual Neto | Economic Net Present Value |
| FIRR | Fasa Interne Financiera de Retorno | Financial Internal Rate of Return |

Others

| | | |
|---|---|---|
| BOD | Demanda Bioquimica de Oxigeno (DBO) | Biochemical Oxygen Demand |
| DO | Oxigeno Disuelto (OD) | Dissolved Oxigen (OD) |
| EC | Conductividad Electrica (CE) | Electrical Conductivity |
| pH | Concentracion de Ion Hyidrogeno | Hydrogen-ion Concentration |
| D.A. | Area de Drenaje | Drainage Area |
| EL. | Sobre nivel de mar | Elevation Above Mean Sea Level |
| MSL | Principal Nivel de mar | Mean Sea Level |

# SUMMARY

# Summary

## 1. Background of the Project

1.1 Agriculture in Costa Rica engages about 1.1 million people, or about 45.5% of total population, and holds the largest share of 22% in the country's GDP, thus forming the foundation of the Costa Rican economy.

In the five-year period from 1980 to 1985, Costa Rica recorded a sluggish or minus growth in GDP, and this is attributed to the downtrend of agricultural production which has sustained the country's domestic economy for many years. The downtrend was notable especially for export crops such as bananas, cacao and sugar canes whose production dropped sharply owing to the fluctuations in international market prices.

Since the country lacks in natural resources and has few export items that can substitute for farm produce, its domestic economy depends heavily on agriculture. The socio-economic condition in the country is therefore influenced directly by the trend of agricultural production.

1.2 In 1986, the Government of Costa Rica formulated " La Agricultura de Cambio" (Change of Agriculture) as a long-term national plan aimed at agricultural development.

Under this plan, the whole country is divided into six regions to introduce new crops according to the characteristics of each individual region and to augment the production of existing crops from a long range point of view.

The Government is fully aware that the projected increase in agricultural production calls not just for the productivity improvement but also for the modernization and improvement of rural communities and elevation of farmer's living standards.

1.3 Against this background, the Government of Costa Rica made a request to the Japanese Government in November 1985 for technical cooperation in formulating a master plan of the Limon Integrated Agricultural Development Project.

In compliance with this request, a "Scope of Work" was agreed upon in August 1986 between the Japan International Cooperation Agency (JICA) and the Government of Costa Rica, and a Study Team dispatched by JICA made a field study twice in Costa Rica, beginning in February 1987, and completed the study at the end of June 1988. This report presents the results of master plan study of the Project.

## 2. Physical Condition in the Study Area

2.1 The Study Area is a low-lying area embraced in Limon Province, which extends along the Caribbean Sea at a distance of about 160 km to the east of San Jose, the capital of Costa Rica. It is a triangular area facing the Caribbean Sea on the northeast, Rio Reventazon on the northwest, and National Route 32 and Rio Toro on the south. National Route 32 links the Area with San Jose (about 2.5 hours by car), and Limon Port in Limon City is the largest trade port in the country. Hence, it can be said that the Area is conveniently located for transportation with other parts of the country.

2.2 The area covered by the Study Area, as measured using a topographic map with a scale of 1/50,000, is 67,000 ha. The land use classification in this 67,000 ha area is as shown below.

| | |
|---|---|
| Cultivated land (incl. non-cropping land) | 27,900 ha |
| Natural grassland | 14,580 |
| Forest land | 20,820 |
| Housing site, etc. | 3,700 |
| TOTAL | 67,000 ha |

2.3 A geological study indicates that the Study Area is an alluvial fan formed by sediment transportation of rivers, and belongs to the Quarternary sedimentary stratum. The low-lying land near the coast is covered with the recent deposits such as humus, clay and marine sediments.

The highest elevation in the Area is 115 m and the lowest is about 1 m. The elevation in the Area is distributed as follows.

| | | |
|---|---|---|
| Elevation of | 20 m and over | : 12.8% |
| " | " 10 to 20 m | : 30.8% |
| " | " 2 to 10 m | : 45.1% |
| " | " 2 m and under | : 11.3% |

Thus, about 76% of the entire area has an elevation of 2 - 20 m.

About 13% of the Study Area is a forest land covered with a tropical rain forest, which is distributed mostly in the low-lying area along the Navigable Canal.

The Study Area is a tropical rain forest climate. Annual average rainfall is 3,500 mm, and there is no clear distinction between the dry season and the wet season. The rainfall in the February - March period and the September - October period is somewhat smaller than in other seasons of the year. March records the smallest rainfall of about 150 mm and December the largest of about 450 mm. Temperature is 25.3° C on the annual average, and goes down to the lowest of 19.6° C in January.

Groundwater table averages 0.3 to 0.5 m below the ground surface owing to the poor drainage condition in the Area. A water quality test conducted for ten wells used for obtaining drinking water in the Area disclosed that 70% of all test wells were contaminated by coliform group.

## 3. Socio-Economic Condition

3.1 The Study Area belongs to Limon Province, and stretches over two Cantons and five Districts. There are about 4,400 farm households with an estimated population of about 19,900 in the rural communities in the Area. The unemployment ratio in these cantons and districts, as disclosed in the 1984 Census, is 9.3% which is 1.8% higher than the national average of 7.5%.

3.2 Roads in the Study Area have a total length of about 273 km and a density of 4.1 km/1,000 ha. Rural roads leading to fields are virtually non-existent. Well-paved roads are not found in the Area, with the exception of the 35 km section of National Route 32 which runs along the southern rim of the Area. Roads leading to banana plantations are generally maintained in good conditions, but those in the farmland and villages are left without maintenance service and become impassable in many parts when it rains. Bridges over the large rivers flowing through the Area are built only on the national highway, so that the inhabitants wishing to go to the other side of these large rivers are forced to go all the way to the national highway or cross the river by boat.

3.3 The children in the Area are given compulsory education at 41 schools, including 6-year course primary schools and high schools. The number of schools is thus sufficient, but there is a shortage of educational equipment and teachers. The percentage of school attendance is quite high, registering 90% for primary schools and 75% for high schools. In addition to these compulsory education facilities, three high schools, a branch of the University of Costa Rica (Faculty of Agriculture), and a private university are found in the Area.

3.4 Public health and medical service is offered at the Central Public Health Center in Siquirres and institution belonging to the Ministry of Health, and its branches are in six places. A traveling clinic is found in Bataan, and there are eight clinics providing educational and nutritional guidance service to infant homes. As

for hospitals, there is only one in Limon City.

3.5 Since there is no water-supply system covering the rural communities, shallow wells (3 - 10 m) are used to obtain drinking water, some of which were found to be contaminated by coliform group in the water quality test. In some villages along rivers (about 25% of total population), the river water is used for various domestic purposes, so that it needs to be boiled before using it for drinking purpose.

In Limon, Siquirres and Bataan, water pumped up from community wells is supplied to the inhabitants, but this well water supply system has no sterilization facilities.

3.6 Electricity is supplied to about 80% of all households in the rural communities. The distribution line construction work is in smooth progress at present to supply electricity to new settlement areas which are now excluded from the power service system. Accordingly, the area is exempted from power problems. Electricity is supplied from hydro-power stations using abundant water resources in Costa Rica.

3.7 Urban areas are covered with a well-consolidated telephone service network maintained by automatic telephone exchanges. In rural communities, however, telephone subscribers are limited to a few large-scale farmers and it is often the case that each community has just one telephone installed at a grocery shop, etc. However, it is expected that the telephone service network will be eventually extended to cover all rural communities under the five-year telephone network development project.

3.8 There is a national railway line linking Limon City in the Area and San Jose, but it is operated to provide only two passenger train shuttle services and one freight train shuttle service daily, and the train speed is low. Accordingly, the importance of this line as a means of transportation is low, and buses and trucks are used in

most cases for transportation to and from San Jose. Buses are used for transportation within the Area, but their routes finish at large settlements in the rural communities. This makes it inevitable for the inhabitants living away from the bus routes to put up with considerable inconvenience.

## 4. Drainage Condition

4.1 The Study Area is in the tropical rain belt with the annual rainfall averaging as much as 3,500 mm, but it is delayed in the development of drainage facilities.

No drainage canals are found in the Area excepting those constructed by banana plantations. Drainage is discharged into rivers, but owing to the absence of drainage canals leading from fields to receiving rivers, rainwater collecting in low-lying areas and hollow land cannot be discharged quickly and often causes inundation. Inundation of such low-lying areas and hollow land occurs 3 - 4 times a year, and it has a depth of about 30 - 50 cm and lasts for 3 - 4 days. From the results of the survey, it is considered that an area of about 46,000 ha, including the permanent swamp zone along the Navigable Canal, is in poor drainage condition at present.

4.2 In the greater part of the farmland area, therefore, the drainage condition is poor and the groundwater table is high through the year. The groundwater table averages as high as 0.3 to 0.5 m below the ground surface, which makes the soil moisture in the farmland too large. For this reason, it is impossible at present to expect any large yield except from crops with high wet endurance.

## 5. Flood Condition

5.1 Rivers flowing through the Area do not have a cross-section area large enough to ensure a smooth downflow of flood discharge in their midstream and downstream sections. When there is a heavy rainfall, flood discharge overflows and causes damage to crops. In particular, large rivers have a very large flood discharge because they have mountainous watershed areas where the rainfall reaches an annual average of as large as 3,700 mm.

5.2 From the interviews with local farmers and the field survey of river sections, topography and existing drainage canals, it is estimated that an area of about 17,000 ha is exposed to the danger of direct damage from a flood of the fives rivers in the Area with a probability of five year return period. Flood of these rivers not only imposes direct damage by overflow, but also retards the downflow of their tributaries, thus aggravating the drainage condition in the Area.

## 6. Agriculture in Study Area

6.1 Despite the agriculture is given considerable weight in the socio-economic development of rural communities, its productivity is held low at present mainly because of the lack of agricultural infrastructure and poor drainage condition. Farmland utilization condition is also poor, only 36% of present arable land is used for planting.

6.2 Most farmers in the rural communities are operating on a small scale. About 72% of the farmers are small-scale farmers with a holding of less than 12.0 ha. One of the salient features of farm management in the Area is that banana plantations have total holding of as large as 7,640 ha. These plantations have their own drainage facilities constructed to lower the groundwater table and have succeeded in securing a high productivity (47.0 t/ha) which far surpasses the national average of 43.5 t/ha.

However, some of the canals built by banana plantations do not connect to rivers, so that the farmland areas in the downstream of plantations are exposed to the adverse influence of drainage from such canals.

6.3 As for main crops planted in the Area, perennial crops include bananas, cacao, coconut palms and plantain, and annual crops include rice, maize, kidney beans and tuber crops. Production is large for bananas, cacao and rice, but bananas are grown only by banana plantations.

6.4 Cattle breeding (mainly beef cattle) is conducted in a relatively large scale by making use of the abundant grassland areas, and there are some farm households specializing in stockbreeding. But the productivity is low because the cattle are left natural pasture to graze. A total of about 7,800 heads of cattle are grazed at present in the Area.

6.5 Settlement in the Study Area has been promoted since it was initiated in 1965 by IDA, and there are now 29 new settlement areas covering about 24,000 ha of cultivated land.

The IDA's settlement project differs from other similar projects. The main activity is not to reclaim any unexploited land, but to readjust the land cultivated without permission from absent land-owners or the Government, and sell it in lots to new settlers.

6.6 The farmland in the Study Area is completely devoid of drainage canals and rural roads maintained in good condition excepting those in banana plantations. In the latest settlement areas, however, roads are constructed by IDA and the land allocation is planned to make each lot face the road.

## 7. Agricultural Economy and Marketing

7.1 With the exception of a few large-scale farmers, most farmers in the Study Area are part-time farmers hired by the nearby banana plantations or large-scale farm households. The survey disclosed that non-agricultural income of some small-scale farm households accounts for about 50% of their total income.

7.2 Bananas are exported to the United States and European countries through the marketing channels opened up by the plantations. Other crops are generally collected by brokers and sent mainly to San Jose because no large markets or processing facilities are found in or near the Study Area.

7.3 Agricultural extension service is offered by the Ministry of agriculture and Livestock(MAG) to the existing farm households and by the agricultural Land Development Institute(IDA) to new settlers, but both authorities are prevented from providing the service to all farm households owing to the shortage of extension workers. It can be said however, that farmers in the new settlement areas are given more intensive extension than those in the existing farmland areas.

7.4 There are 42 farmer's organizations or societies/groups in the Study Area, such as 9 cooperatives and 33 development associations.
Among the cooperatives, only 2 cooperatives obtain a profits. Generally, the cooperative activities are inactive, so that the members are not numerous. However, the banana production cooperative is in full activity. To augment the banana production in the future, the Government of Costa Rica has been taken measures in organizing the cooperative.

## 8. Problems in Study Area, and Basic Concept of Development Plan

8.1 Main factors hampering the increased agricultural production in the Study Area include the poor drainage, floods, undeveloped agricultural infrastructure and shortage of roads in the hardware

aspect, and the deficient agricultural extension service, difficulty in obtaining agricultural finance service and absence of well-consolidated marketing channels in the software aspect.

The most influential of these causal factors are the poor drainage condition and floods. However, it is impossible to increase the production simply by implementing drainage improvement and flood protection plans. These plans need to be backed up with upgraded software service and with measures for creating a more affluent living environment for farmers.

The project of overall agricultural development should be promoted not only to increase the production, but also to strengthen social infrastructure, create employment opportunities, and improve the welfare of rural inhabitants.

8.2 The master plan for the integrated agricultural development was formulated with special consideration given to the following points.

a. Development efforts will be focused mainly on small-scale farm households in the low income group.

b. Effective use will be made on the abundant land resource

c. Measures will be taken to improve the income level of all rural inhabitants.

d. Consistency will be maintained with Costa Rica's National Development Plan.

8.3 The following plans were selected for the formulation of the master plan by taking consideration the development potential and natural conditions of the Study Area, factors hampering the increased agricultural production, and the necessity for maintaining consistency between the master plan and the National Development Plan into consideration.

Drainage Improvement Plan
Flood Protection Plan
Agricultural Production Plan
Road Network Plan
Agricultural Infrastructure Improvement Plan
Settlement and Communities Development Plan
Agricultural Promotion Plan

8.4 Since all development plans listed above are closely interrelated, it cannot be justified to implement them separately by establishing a priority order. Accordingly, it is planned that the entire area will be divided into a number of zones and all plans will be implemented in parallel with each other in each zone so as to be able to attain the highest development effect. Since the Area is divided into four Zones by large rivers, it is considered appropriate to divide the Area into four Zones for simultaneous implementation of all projects. The four Zones coincide with the administrative division of the Area.

The area of each Zone as measured using a topographic map (1/50,000) is shown below;

| | |
|---|---|
| Zone A | 10,800 ha |
| Zone B | 19,500 |
| Zone C | 12,600 |
| Zone D | 24,100 |
| Total | 67,000 |

## 9. Outline of Individual Plan

### 9.1 Drainage Improvement Plan

On the basis of survey activities which included field reconnaissance, data collection and interviews with local officers and farmers, the area of 35,200 ha as measured using a 1/50,000 topographic map is considered in need of drainage improvement.

The plan was formulated for construction of drainage canals to realize natural drainage of rainwater into the sea, not for introduction of the pump drainage system which incurs a high maintenance cost. The drainage canals will comprise the principal and secondary canals. The former will be constructed at intervals of 3 - 4 km in the direction perpendicular to the coast, and the latter will be arranged, as a rule, at intervals of 1,000 m in the direction intersetting the principal canals at right angles. The construction of these canals will realize smooth drainage from all fields, lower the groundwater table in the entire farmland area, and raise the production of all crops.

The principal drainage canals will have a total length of about 190 km (new canals: 124 km), and the secondary drainage canals, which are all to be newly constructed, will have a total length of about 219 km.

## 9.2 Flood Protection Plan

The field reconnaissance, interviews with local farmers and river surveying conducted by the Study Team led to the conclusion that the midstream and downstream section of Rio Matina, Rio Chirripo, Rio Pacuare, Rio Barbilla and Rio Reventazon are most vulnerable to flood. This plan will be implemented to construct low flood-protecting embankments in the flood occurrence sections found in the field survey to prevent the flood water from overflowing the river banks and inundating the farmland area.

When these embankments are built, the cultivated land will no longer be exposed to direct flood damage and the influence of backwater of smaller rivers branching from large rivers will be eliminated, so that the drainage condition in the Study Area will be greatly improved.

The embankments to be constructed for flood protection will have a total length of about 118 km.

## 9.3 Agricultural Production Plan

The present low cropping ratio in the Study Area which is due mainly to the poor drainage condition will be increased when the drainage improvement and flood protection plans are completed. These two plans, combined with the new settlement plan, will serve to raise the land utilization rate in the Area to a great extent.

This plan is aimed at increasing the agricultural production and raising the income level of small-scale farmers on the premise that drainage improvement and flood protection measures will be implemented in the Study Area. Accordingly, the plan was formulated for the specific purpose of increasing the cropping area, adopting the multi-cropping system and introducing high-yielding crops.

The new crops to be introduced and the approximate cropping area were determined on the basis of interviews with local farmers and a series of discussions with relevant agricultural organizations, with consideration given to the desires of the Government of Costa Rica and the consistency with the country's Long-Term National Development Plan.

When crops like bananas, cacao, coconuts, plantain,black pepper, rice, maize and kidney beans, are introduced under this project, the agricultural production in the Study Area will be increased notably, bringing about an income about 2.6 times as high as the present level.

## 9.4 Road Network Plan

Roads are indispensable for shipment of agricultural products and transportation of farm machinery and equipment as well as for the daily lives of inhabitants. This plan was included in the master

plan because the absence of well-consolidated road network is one of the causes of the area's retarded development.

The plan will be implemented for construction of main roads, trunk roads and lateral roads. The main road will be surfaced with random paving, but the others will be constructed as gravel roads. When the plan is completed, the total length of roads will be about 233 km, of which about 82 km will be accounted for by newly constructed roads and the remainder by the widened and improved existing roads.

The road density will be increased to about twice the present level after the plan completion, making it possible to link all villages by improved roads, and this will contribute greatly to the area's future development. The plan will cut down the cost of farm product transportation, and the benefit derivable from this cost reduction is estimated at about 29 million colones/year.

## 9.5 Agricultural Infrastructure and Improvement Plan

Transportation of harvested crops and farm machinery in the Study Area is made inefficient by the poor maintenance condition of farm roads in the fields. Furthermore, the absence of tertiary drainage canals makes it impossible to discharge rainwater in the Area where the annual rainfall averages as much as 3,500 mm. To remove these drawbacks which are fatal to effective farmland utilization, this plan will be implemented to improve farm roads and construct tertiary drainage canals in the fields.

In view of the average block size of field, the farm roads will be arranged at intervals of 1,000 m and the tertiary drainage canals at intervals of 200 m. By connecting these roads and canals with the lateral roads and secondary drainage canals, the agricultural infrastructure of the Area will be strengthened and the farm productivity will be increased in all fields.

## 9.6 Settlement and Rural Development Plan

The drainage improvement and flood protection plans will open up the possibility of utilizing the hitherto unused land for agricultural production. This plan formulated on the basis of the land classification, land ownership and locations of existing settlement areas, aims at creating a new settlement with an area of about 11,500 ha. The land in this new settlement area will be sold in lots of 10 ha to general farm households and in lots of 15 ha to cattle breeding farm households according to the practice followed in the current settlement project. When this settlement plan is completed, the Study Area will have an additional 830 farm households.

This plan should preferably be implemented by the IDA because it has been promoting the settlement in the Study Area for many years. Public facilities such as clinics, assembly halls, primary schools, dormitory buildings for teachers, and water supply facilities will also be constructed in the settlement and existing villages under the plan.

## 9.7 Agricultural Promotion Plan

This plan was formulated to provide the extension services necessary for upgrading the technical level of farmers and helping them attain higher management efficiency and productivity.

It includes a number of programs all intended to attain the above objective, such as the agricultural support organization reinforcement program aimed at strenghtening the agricultural extension services, the farmers' organization improvement program aimed at organizing producers' cooperatives, farm produce processing, and marketing facilities improvements programs to increase the production of cacao and tuber crops, and the mechanization center program to promote the introduction of farm mechanization.

9.8 Development plans mentioned above can be summarized as follows.

Development Plans

| (Plan Name) | (Plan outline) | | |
|---|---|---|---|
| 1. Drainage improvement plan | Principal drainage canals, unlined, | | |
| | | New construction | 124.0 km |
| | | Rehabilitation | 43.9 km |
| | | Existing | 22.2 km |
| | Secondary drainage canals, unlined, | | |
| | | New construction | 218.7 km |
| 2. Flood protection plan | Embankment of Rio Matina, Rio Chirripo, Rio Pacuare, Rio Barbilla, and Rio Reventazon | | |
| | | Embankment length | 118.2 km |
| 3. Agricultural production | Bananas, cacao, coconuts, plantain, peper, rice, maize, kidney beans, tuber crops | | |
| | | Cattle raising | Beef cattle |
| | | Farming pattern | 7 patterns |
| 4. Road network plan | | New construction | 81.5 km |
| | | Rehabilitation | 151.3 |
| | | Total | 232.8 km |
| 5. Land consolidation plan | Teritiry drainage canals and farm roads in the area of 44,240 ha | | |
| 6. Settlement and rural development plan | Public facilities in three new settlement areas | | |

| | | |
|---|---|---|
| 7. | Agricultural promotion plan | a. Agricultural support organization reinforcement program |
| | | b. Farmers' organization improvement program |
| | | c. Farm produce processing and marketing facilities improvements program |
| | | d. Farm mechanization center program |

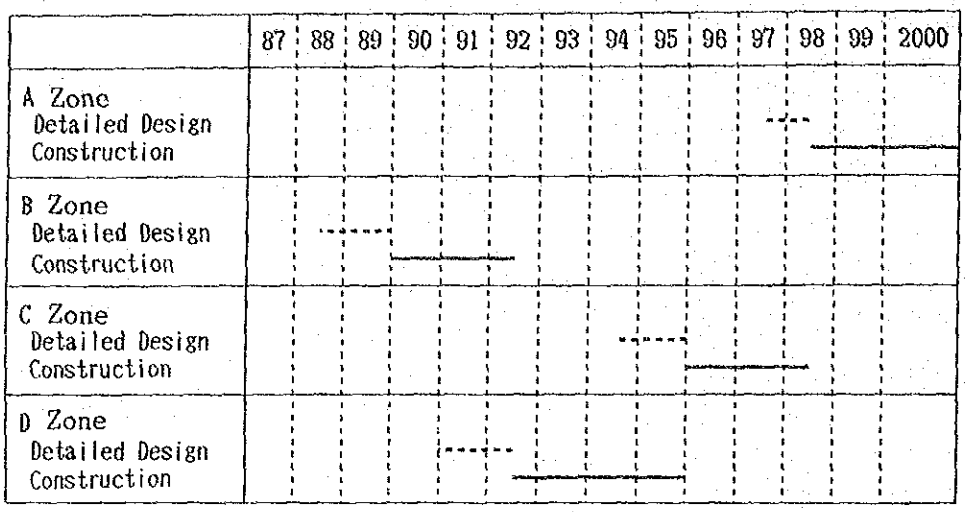
## 10. Preferential Development Zone

10.1 The development priority of the four zones was examined to on the promise that all development plan in an integrated manner in each zone will be carried out.

Evaluation items subjected to a comprehensive analysis to determine the development priority are the economic efficiency (internal rate of return, construction cost), urgency of project implementation, size of area calling for drainage improvement, number of small-scale farm households, site condition, and demonstration effects. As a result, top priority was given to Zone B, followed by Zone D, Zone C and Zone A in this order.

## 11. Project Implementation Plan

11.1 Upon consultation with the pertinent Costa Rican authorities, it was agreed that the Project will be implemented over a period of 12.5 years for completion in 2000. The Project implementation schedule is shown below.




11.2 Capital outlay required for the Project completion is estimated at about US$89,309,000 (¢5,474,641,000), as shown below.

Unit : 1000 US$

| Zone, Area / Item | A (7,020 ha) | | | B (12,580 ha) | | | C (7,560 ha) | | | D (17,080 ha) | | | Total (44,240 ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Currency | | Total | Currency | | Total | Currency | | Total | Currency | | Total | Currency | |
| | | F/C | L/C | | F/C | L/C | | F/C | L/C | | F/C | L/C | | F/C | L/C |
| Drainage improvement | 8,662 | 5,987 | 2,675 | 13,654 | 9,429 | 4,225 | 7,177 | 4,959 | 2,218 | 11,615 | 8,043 | 3,572 | 41,108 | 28,418 | 12,690 |
| Projection of flood | 1,566 | 962 | 604 | 2,724 | 1,713 | 1,011 | 3,573 | 2,055 | 1,518 | 9,837 | 6,003 | 3,834 | 17,700 | 10,733 | 6,967 |
| Road improvement | 1,566 | 1,044 | 522 | 3,181 | 2,137 | 1,044 | 2,953 | 2,023 | 930 | 5,073 | 3,442 | 1,631 | 12,773 | 8,646 | 4,127 |
| Settlement consolidation (public facilities) | 65 | -- | 65 | -- | -- | -- | 33 | -- | 33 | 147 | -- | 147 | 245 | -- | 245 |
| Detail Design & supervision | 1,052 | 1,052 | -- | 1,872 | 1,872 | -- | 1,214 | 1,214 | | 2,584 | 2,584 | -- | 6,722 | 6,722 | -- |
| Total | 12,911 | 9,045 | 3,868 | 21,431 | 15,151 | 6,280 | 14,950 | 10,251 | 4,699 | 29,258 | 20,072 | 9,184 | 78,548 | 54,519 | 24,029 |
| US$/ha | 1,839 | | | 1,704 | | | 1,978 | | | 1,713 | | | 1,775 | | |
| Price contingency | 1,769 | 1,239 | 530 | 2,836 | 2,078 | 860 | 2,048 | 1,404 | 644 | 4,008 | 2,750 | 1,258 | 10,761 | 7,469 | 3,292 |
| Total | 14,680 | 10,284 | 4,398 | 24,387 | 17,227 | 7,140 | 16,998 | 11,655 | 5,343 | 33,264 | 22,822 | 10,442 | 89,309 | 61,988 | 27,321 |
| US$/ha | 2,091 | | | 1,937 | | | 2,248 | | | 1,948 | | | 2,018 | | |

11.3 It can reasonably be said that National Groundwater, Irrigation and Drainage Service (SENARA) is the proper body to execute this comprehensive agricultural development project. Considering, howeverver, that the Project is intended to be implemented in a broad expanse of area to realize development in versatile fields, it is advisable that SENARA organizes a joint committee with the participation of MAG, IDA and JAPDEVA (Board for Administration of Ports and Development of the Atlantic Basin) to formulate a policy for

the project execution by a consensus of opinion of all committee members.

## 12. Project Benefits

12.1 In 2000 when this integrated agricultural development project is completed, the Study Area will emerge as an advanced farming area favorably conditioned for high-productivity farm management. In addition, the following benefits can be derived from the Project implementation.

a) Improvement of agricultural productivity
Since the Project will remove all factors hampering the area's agricultural development, the Project will realize a notable increaze in agricultural production.

b) Improvement of income level
The augmented agricultural production resulting from the Project implementation will push up the income level of the area's farming population, especially that of small-scale farmers.

c) Increase of employment opportunities
The employment opportunities in the Area will be widened by the establishment of a new settlement, utilization of hitherto unexploited land and establishment of processing and marketing facilities.

d) Revitalization of regional economy
The increased agricultural production will give an enormous impetus to the economic activities in and around the Area.

e) Promotional impact on the regional development of the Atlantic Region
The completion of the Project gives a strong promotional impact on the development of the Atlantic coast farmland area with an acreage of about 300,000 ha where the conditions are similar to those of the Study Area, producing implications for model development.

## 13. Conclusion

13.1 In Costa Rica, the Study Area has been known as one of the areas suitable for agricultural production, but its development has been hapmered owing to the poor drainage condition, frequent occurrence of flood, and the lack of agricultural extension and supporting services. The Study Team formulated a master plan for comprehensive agricultural development of this 67,000 ha area.

The master plan proposes the implementation of a number of development plan formulated on the basis of the survey results to realize a phenomenal agricultural development and widen employment opportunities in and around the Area as well as to improve the welfare of rural inhabitants. The plans included in the master plan are the drainage improvement plan, flood protection plan, road network plan, land consolidation plan, settlement and rural development plan, and agricultural promotion plan.

The Study Area was divided into four zones for simultaneous implementation of the Project, and the feasibility of this integrated development project was measured against the yardstick of various economic as well as technical factors, which led to the conclusion that the Project is fully justifiable. The development priority of the four blocks was also examined.

It is hoped that a detailed feasibility study will be made for each individual plan in each zone as the next step toward the realization of the area's integrated development project.

## 14. Recommendations

The Team wishes to make the following recommendations on the basis of its master plan formulation and examination work.

14.1 The development priority should be given to Zone B, then to Zone D, Zone C and Zone A in this order. As the first necessary step toward the integrated agricultural development, a feasibility study should be made for Zone B to examine the technical and economic viability of each plan before proceeding to the construction work.

14.2 The settlement and rural development plan, the land consolidation plan and the agricultural promotion plan should preferably be implemented by their respective executing agencies in parallel with the progress of construction work.

14.3 SENARA will assume full and direct responsibilities for the execution of the Project. For the purpose of actual project implementation, however, it is recommended that SENARA organizes a joint committee with the participation of IDA, MAG and JAPDEVA.

# CHAPTER 1 INTRODUCTION

# Chapter 1 Introduction

## 1.1 Background of the Study

The Government of Costa Rica has put emphasis with highest priority on the promotion of the agricultural sector to improve the national socio-economic conditions. The state measures have been taken in line with this policy, and some agricultural development projects are already being executed in the Pacific Region.

On the other hand, in the Atlantic Region, banana production has been performed from early in this century. Bananas are in a position as the next main crop to coffee in the Costa Rica's export products.

This region is a flatland with high rainfall, hence it has poor drainage. There are many unused and low productive lands. In addition, the farm size of general farm households is small and their farming is unstable.

Thus, in 1984, the Government of Costa Rica established a development program with the object of agricultural development in the Atlantic Region, (Programa de la Rehabilitacion de Tierra, Control de Avenida y Drenaje de las Areas Agricolas en la Vertiente Atlantica).

To accelerate the program, the Government of Costa Rica selected the Limon area as a pilot area in this development project. It is located in the middle part of the Atlantic Region. Then, in November, 1985, the Government made a request to the Japanese Government for technical cooperation in the study of the Limon Integrated Agricultural Development.

In August, 1986, in compliance with this request, the Japan International Cooperation Agency (JICA), the official agency responsible for implementing technical cooperation programs, sent a preliminary cum scope of work mission to discuss the implementation manner to the Study, including a master plan study of the Project and a feasibility

study for the area selected by the master plan study. The scope of work was agreed upon between the JICA and the Government of Costa Rica.

In accordance with this scope of work, the study team dispatched by the JICA made field study twice in Costa Rica, beginning in February, 1987. This report presents the master plan study of 67,000 ha of the Project.

## 1.2 Objectives of the Study

The objectives of the Study are as follows;

(1) To formulate the master plan on the Limon Integrated Agricultural Development Project.

(2) To select the area for feasibility Study from the Study Area.

## 1.3 Study Area

The Study Area is located in the Atlantic Region with the Caribbean Sea to the northeast, Rio Reventazon to the northwest, and National Route 32 and Rio Toro to the south.

The Study Area for a master plan covers 67,000 ha in the Limon area(see Location Map).

# CHAPTER 2 GENERAL FEATURES OF COSTA RICA

## Chapter 2. General Features of Costa Rica

### 2.1 Physical Conditions

The Republic of Costa Rica is situated in the southern part of Central America at $8^{o}$ - $11^{o}$ north latitude and $83^{o}$ - $86^{o}$ east longitude. The country lies between the Caribbean Sea to the east and the Pacific Ocean to the west and shares its borders with Nicaragua to the north and Panama to the south. The territory covers an area of 51,000 $km^2$.

In central part of the country, the mountain ranges including Guanacaste, Central and Talamanca run from northwest to southeast, and the country is classified into three zones; the Central Highland, and the Coastlands facing the Pacific and Caribbean Sea, according to altitude and geographic feature.

The Central Highland is plateau with an average altitude of over 1,000 m(above sea level), and to the southeast of the plateau, volcanos soaring over 3,000 m(above sea level) stand like sentries in a row.

The Pacific Coastland is relatively mountainous and the coastline having many gulfs and inlets is full of variety. In contrast, the Caribbean Coastland is comparatively flat and the coastlines straight and monotonous.

Climate conditions range from tropical along the coasts to temperate in the highlands. The Central Highland and Pacific Coastland have two seasons -- wet and dry, whereas the Coastland along the Caribbean Sea has an annual average rainfall of more than 3,000 mm, so the climate in this zone is humid.

## 2.2 Socio-economic Structure

### 2.2.1 Economic Growth

The Costa Rican economy is based on agriculture and livestock, which account for about 20% of the Gross Domestic Product (GDP) for 1985 (see Table 2.2.1). The GDP for Costa Rica in 1985 reached 9,790 million colones in constant price of 1966. The real annual average growth rate over the five years from 1981 to 1985 remained at 0.4%, a low rate resulting from minus growth in 1981 and 1982. However, GDP grew 2.9% in 1983 and 7.4% in 1984, and the economy was stabilized and the production sector revitalized from 1983, as the outcome of the government's tight economic policy.

Though the growth rate was relatively slow in 1985, it is currently stable.

The minus growth in the early 1980s was caused mainly by the sluggishness of the international market for agricultural products, protective policy, decrease of exports by the recession in developed industrial countries, and difficulities to conduct the proper policy by the country's high debts.

The 1985 GDP per capita was 71,723 colones (US$1,420), showing a high value in Central American countries. (see Table 2.2.2)

### 2.2.2 Demographic Structure

According to the 1984 census, the total population of Costa Rica is 2,416,809, with 47.3 persons per square kilometer. The distribution of the population in urban and rural areas is 44.5% and 45.5% respectively (see Annex A Table A.1). The population increased by an annual average of 2.9% over the decade 1973 to 1984, as shown in Table 2.2.3 and 2.2.4.

Table 2.2.3 Area and Population

| Province | Area ($km^2$) | Population (habitants) | Density (hab./$km^2$) |
|---|---|---|---|
| San Jose | 4,957.1 | 890,434 | 179.6 |
| Alajuela | 9,718.1 | 427,962 | 44.0 |
| Cartago | 3,031.1 | 271,671 | 89.6 |
| Heredia | 2,673.5 | 197,575 | 73.9 |
| Guanacaste | 10,199.6 | 195,208 | 19.1 |
| Puntarenas | 11,302.2 | 265,883 | 23.5 |
| Limon | 9,218.4 | 168,076 | 18.2 |
| Total | 51,100.0 | 2,416,809 | 47.3 |

Source: Census 1984

Table 2.2.4 Increase Rate in Population

Unit : 1,000 habitants

| 1973 | 1977 | 1984 | 1973-1984 Increase Rate(annual rate) |
|---|---|---|---|
| 1,871.8 | 2,048.1 | 2,416.8 | 2.9 % |

Source : Census of 1973,1977 and 1984

On the other hand, the population of economic activities (over the age of 12) is 804,192 of which 746,860 (92.5%) are employed; thus the unemployment rate is 7.5%. 32% of the working population is engaged in agriculture, forestry and livestock industries (see Table 2.2.5 and 2.2.6).

Table 2.2.5 Economic Activities Population

| Employment Population | Unemployment Population | | | Total |
|---|---|---|---|---|
| | Temporary Unemployment | Completely Unemployment | sub-total | |
| 746,860 | 9,767 | 47,566 | 57,333 | 804,193 |
| 92.5% | | | 7.5% | 100% |

Source : Census 1984

Table 2.2.6 Economic Activities Population Classified by Industry

| Type of Industry | Economic Activities Population(habitant) | Ratio (%) |
|---|---|---|
| Agriculture,fishery | 249,400 | 32 |
| Mining | 1,549 | – |
| Manufacture | 106,046 | 13 |
| Electricity, gas and Water supply | 9,035 | 1 |
| Construction | 41,760 | 5 |
| Commerce | 87,555 | 11 |
| Transport,warehouse and Communication | 20,475 | 3 |
| Finance and Insurance | 20,267 | 3 |
| Public services | 176,093 | 22 |
| Professional | 82,246 | 10 |
| Total | 794,426 | 100 |

Source: Census 1984

## 2.2.3 National Finance

According to financial statements of the National Banking Systems (SBN), balanced national finance will soon be attained as the economy recovers. On the other hand, the amount of foreign debts is increasing gradually, reaching 111,778 million colones (US$2,210 million) as of the end of 1985(see Annex A Table A.2).

Government finance has maintained steady annual average revenue and expenditure from 1983 to 1985 (13.7% and 12.0% respectively) through a strong financial reconstruction policy. The ratio of capital raised to meet financial shortages in 1985 was in the ratio of nearly fifty-fifty for domestic and foreign countries (see Annex A Table A.3).

The balance of foreign loans was US$950 million as of the end of 1985. (see Annex A Table A.4)

### 2.2.4 International Trade

The main agricultural products of Costa Rica are coffee, bananas and beef. These products are exported at the rate of about 32% for coffee, about 22% for bananas, and about 6% for beef. Though the actual export record in fiscal year 1985 was US$963 million, but the figure varies from year to year depending on international market situation.

Over 85% of total exports go to the United States, West Germany and other European countries.

In particular coffee, bananas and beef exports to the United States have been increasing. Exports to Western Europe tend to maintain a constant level.

Recently, the Government has emphasized the promotion of traditional products such as plantain.

On the other hand, seeing from the record of official, the mining and primary materials for industry and non-durable goods account for about 57% of the total amount of imports and primary agricultural products reach about 10%.

Costa Rica's international balance of payments is indicated a minus value by unfavorable trade balance, but the recent trend has been improved as shown in Annex A Table A.8.

## 2.3 Administrative Organization

### 2.3.1 Central Government

The Republic of Costa Rica is a constitutional democratic country, with a president and cabinet ministers.

The present government was elected by the national election in 1986,

and will serve out its term until 1990.

The government structure is as below.

1) National Legislature
   (Asamblea Legislativa)
2) Presidential Office
   (Secretaria de la Presidencia de la Republica)
3) Ministry of Foreign Affairs and Culture
   (Ministerio de Relaciones Extranjeros)
4) Ministry of Interior and Justice
   (Ministerio de Interior Justicia)
5) Ministry of Economy, Industry and Commerce
   (Ministerio de Economia y Comercio)
6) Ministry of Exports
   (Ministerio de Exportaciones)
7) Ministry of Finance
   (Ministerio de Hacienda)
8) Ministry of Public Education
   (Ministerio de Educaccion Publica)
9) Ministry of Culture, Youth and Sports
   (Ministerio de Cultura, Juventud y Depoprtes)
10) Ministry of Public Construction and Transport
   (Ministerio de Obras Publicas y Transporte)
11) Ministry of Health
   (Ministerio de Salud)
12) Ministry of Agriculture and Livestock
   (Ministerio de Agricultura y Ganaderia)
13) Ministry of Labor and Social Insurance
   (Ministerio de Trabajo)
14) Ministry of Public Security
   (Ministerio de Seguridad Publica)
15) Ministry of National Planning and Economic Policy
   (Ministerio de Planificacion Nacional y Politica Economica)

### 2.3.2 Local Administrative Organization

Local administration of Costa Rica is divided into seven provinces, and these are further subdivided into cantons. However, there are no provincial administrative organizations. In each canton, an elected municipal executive administers the canton under the direct guidance of IFAM.

*The number of the canton and district in each province is as below:*

| Province | Canton (Number) | District (Number) |
|---|---|---|
| San Jose | 20 | 107 |
| Alajuela | 15 | 106 |
| Cartago | 8 | 46 |
| Heredia | 10 | 43 |
| Guanacaste | 11 | 47 |
| Puntarenas | 11 | 43 |
| Limon | 6 | 23 |

### 2.3.3 Agricultural Institutions

Agricultural institutions concerned with various fields such as farm credit, agricultural development, agricultural support, and farmer's organizations are as follows (see Annex A):

1) National Banking System (Sistema Bancario Nacional - SBN) - Agricultural Credit
   a. Banco Anglo Costarricense - BAC
   b. Banco Central de Costa Rica - BCCR
   c. Banco Credito Agricola de Cartago - BCAC
   d. Banco de Costa Rica - BCR
   e. Banco Nacional de Costa Rica - BNCR

2) National Production Council(Consejo Nacional de Produccion - CNP)

- Price control for basic foods and promotion of agricultural production.

3) National Cooperative Fomentation Institute
(Instituto Nacional de Fomento Cooperativos - INFOCOOP)
- Promotion of Cooperative

4) Agrarian Development Institute
(Instituto de Desarrollo Agrario - IDA)
- Land title allocation and execution of settlement program

5) Board for Administration of Ports and Development of the Atlantic Basin
(Junta de Administracion Portuaria de Desarrollo Economico de la Vertiente Atlantica - JAPDEVA)
- Administration of ports and development of the Atlantic basin

6) Coffee Office (Oficina del Cafe - OFICAFE)
- Administration of coffee production

7) Rice Office (Oficina del Arroz - OFIARROZ)
- Administration of rice production

8) National Seed Office (Oficina Nacional de Semillas - ONS)
- Seed production and its quality control

9) Grains and Seeds Research Center
(Centro de Investigaciones de Granos y Semillas - CIGRAS)
- Grains and seeds research

10) National Groundwater, Irrigation and Drainage Service
(Servicio Nacional de Aguas Subterraneas, Riego y Avenamiento - SENARA)

- Development of groundwater and implementation of irrigation and drainage

11) National Banana Association
(Asociacion Bananera Nacional - ASBANA)
- Banana production and development and research of perennial crops.

## 2.4 Agricultural Sector

The agricultural sector forms the basis of the Costa Rican economy, making a great contribution to the GDP producing employment opportunities and serving as a source of foreign currency income.

49% of primary agricultural production is accounted for by coffee, cacao and sugar; about 9% from other agricultural products, about 27% from livestock, about 3% from forestry; and about 2% from others. (See Annex A Table A.9)

Some 32% of total labor force is engaged in the agricultural sector. Agricultural products account for about 70% of total exports. Approximately 60% of these exports are traditional products including coffee - about 32%, bananas - about 22%, beef - about 5%, sugar and cacao- about 2 %.

In particular coffee and banana production has increased by 5% annually in the early 1970s due to a boom of international markets; however, the increase was a little less than about 1 % early in the 1980s owing to the sluggish international market from the mid-1970s.

Non-traditional agricultural products such as non processed vegetables, fruits, flowers, spices and fish account for nearly 9% of exports.

Nearly 10% of total import is consumed for foodstuffs such as wheat, maize, beans, dairy products,sorghum and oil seeds.

## 2.5 National Agricultural Development Plan

### 2.5.1 Agricultural Development Plan

The present government of Costa Rica, established a new agricultural development plan called "Change of Agriculture"(La Agricultura de Cambio), in 1986.

The new agricultural development plan aims to select and introduce new agricultural crops for export and to increase traditional agricultural products. This is a long term plan, taking a separate approach for each of the six regions; Chorotega, Pacifico Central, Brunca, Central, Huetar Norte and Huetar Atlantica, to suit the specific local characteristics.

#### (1) Objectives of Agricultural Development Plan

The new agricultural development plan is summarized in the following five items:

1) To increase basic food products and food supply depending on the taste and income of the consumers.

2) To increase agricultural products for export and improve productivity.

3) To develop and increase new agricultural products for export.

4) To promote provision and registration of agricultural land for landless farmers and support services of small-scale farmers.

5) To increase employment opportunities and farmers' income in the agricultural sector.

To this end, the government will implement the plan in the following three stages:

a. Short term plan: Annual agricultural production plans, since 1986

b. Medium-term plan: Five-year agricultural production plan, from 1986 to 1990

c. Long-term plan: Agricultural production plan for after 1990

(2) Development Regions and Crops

Development regions and crops covered by the agricultural development plan are as follows:

| | Region | Crops |
|---|---|---|
| a. | Chorotega | sugarcane, soybeans, cotton, maize, fruit, livestock |
| b. | Pacifico Central | fruit, african-palm, soybeans, livestock, fish |
| c. | Brunca | african-palm, cacao, fruit, soybeans, livestock |
| d. | Central | vegetables, tobacco, industrial crops |
| e. | Huetar Norte | cacao, macadamian nuts, fruit, livestock |
| f. | Huetar Atlantica | banana, cacao, plantain, coconuts, macadamian nuts, livestock |

### 2.5.2 Actual Agricultural Development Project

The former government (1982 to 1986) established irrigation, drainage and rural development projects in several regions for promotion of agricultural production.

To achieve the new agricultural development plan, the present government is going to complete the projects begun by the former government.

Below are actual on-going projects and expected project to be materialized without delay. SENARA is involved in most of these projects.

(1) Arenal - Tempisque Agricultural Development Project
(Proyecto de Arenal-Tempisque)

This is an irrigation project for the Guanacaste Region on the Pacific Coast. The total project area is approximately 63,000 ha.

This project consists of four stages; the first and second stages in the Arenal and Zapandi area, approximately 13,000 ha, begun in 1986.

(2) Itiquis Irrigation Project
(Proyecto de Riego de Itiquis)

This is an irrigation project for agricultural land of approximately 5,000 ha in the Alajuera district in the Central Region.

The main object of the project is to provide irrigation for agriculture. Approximately 600 to 2,000 farmers will get benefit from the project.

(3) Small-Scale Irrigation and Drainage Projects
(Proyecto Pequena Irrigacion)

The Government has devised approximately 60 small-scale irrigation and drainage projects, each covering 50 to 2,000 ha.

The Gamatilla project aiming mainly to improve drainage in the Puriscal Region, is under implementation.

(4) Agricultural Development in the Atlantic Coastal Region
(Proyecto de Desarrollo Agricola en la Zona Atlantica)

This project aims at agricultural rural development of 300,000 ha in the Atlantic Coastal Region, and was formulated by IDA in 1984.

The principal purpose of the project is to enable the small- and medium-scale farmers to improve their income and standard of living, and also includes the projects of road, cacao production, coconut production and livestock.

# CHAPTER 3 PRESENT CONDITION OF THE STUDY AREA

# Chapter 3. Present Condition of the Study Area

## 3.1 Physical Condition

### 3.1.1 Location

The Study Area in Limon Province is a 670 $km^2$ low-lying area facing the Caribbean Sea, located about 160 km to the east of the country's capital, San Jose. It is a triangular zone with the Caribbean Sea to the northeast, Rio Reventazon to the northwest, and the National Route 32 and Rio Toro to the south.

The Study Area is linked to the capital by the highway, and can be reached in two and half hours. It has the biggest shipping port in Limon, and thus has favorable transport conditions.

Location map of the Study Area is shown in Fig. 3.1.1.

### 3.1.2 Topography and Geology

#### (1) Topography

The Study Area and its hinterland lie between the Central and the Talamanca mountain ranges which run through from northwest to southwest in the central part of the country to the Caribbean Sea, having a watershed area of 5,650 $km^2$ in total.

Topographically, the whole area can be roughly divided into the steep mountainous area ranging from 115 m to 3,400 m above sea level and the coastal area less than 115 m above sea level. The mountainous terrain accounts for about 90% of the whole area (4,980 $km^2$), and has an average gradient of 1/50.

In the coastal area, a contour line with an elevation of 10 m, runs parallel to 12 km inside of the coastline, divides the Study Area into sea side and mountainous side areas.

The coastal area between this contour line and the coastline, has an average gradient of 1/1,200, however, in the area lying a 5 km wide parallel to the coast, the land declines gently with a gradient of 1/5,000. On the other hand, the average gradient of the side closer to the mountains is 1/500. The slope becomes steeper as the land nears National Route 32 which runs along the skirts of the mountains, and the gradient reaches 1/100 to 1/200.

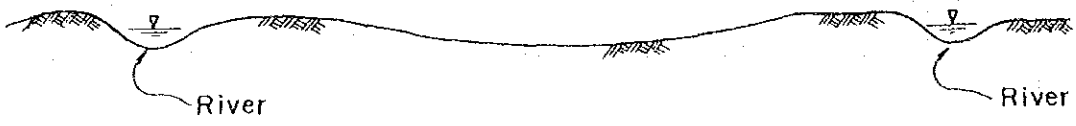
The maximum elevation in the Study Area is 115 m (above sea level) and the minimum about 1 m (above sea level). Areas with different elevations can be broken down as follows; (see Table 3.1.1 and Fig. 3.1.2)

| | | |
|---|---|---|
| Elevation of 20 m and over | : | 12.8% |
| " " 10 to 20 m | : | 30.8% |
| " " 2 to 10 m | : | 45.1% |
| " " 2 m and under | : | 11.3% |

In view of the above, on area between 2 m and 20 m above sea level accounts for about 76% in total.

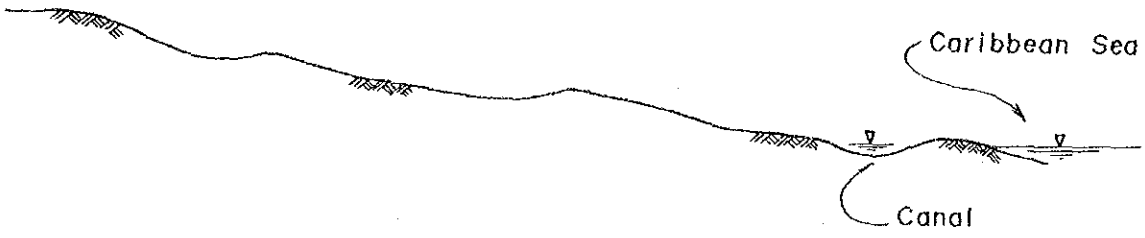
The topographical features in the Study Area are as follows:

Topography of the land parallel to the coastline is illustrated roughly as below.




Most areas between large rivers, having mainly mountainous watershed, are slightly low, so that the drainage in these area is dependent on the small- and medium-size rivers. However, these rivers have insufficient discharge capacity because of their narrowness and this condition causes poor drainage.

The land is sloped perpendicular to the coastline. However, the land does not slant uniformly to the sea, but undulates considerably as shown below.




The above undulated topography leads to flooding in the hollow areas and causes rivers to overflow.

The characteristics of the topographical featutes make a principal points on the occasion of considering the cause of poor drainage and planning the drainage systems.

The Study Area can be divided into four topographical zones surrounded by large rivers based on topographical traits. Each zone forms one drainage area.

Zone A : Rio Toro - Rio Matina
Zone B : Rio Matina - Rio Madre de Dios
Zone C : Rio Madre de Dios - Rio Pacuare
Zone D : Rio Pacuare - Rio Reventazon

In the Study Area, as there are no bridge except for National Route 32, therefore the socio-economic activities in the area separated by these rivers, are independent from one another. In addition, the administrative districts are divided by these rivers as below. (see Fig. 3.1.2)

| Zone | Canton | District |
|---|---|---|
| A | Matina | Carrandi |
| B | " | Bataan |
| C | Siquirres | Pacuarito |
| D | " | Siquirres |

Therefore, the Study shall be carried out based on these four zones.

(2) Geology

The geology of the Study Area is shown in Fig. 3.1.2. The mountainous area is covered by sedimentary and volcanic rocks of the Tertiary, whereas, the coast land is an alluvial fan formed by river sedimentation of the Quaternary.

The low-lying area near the coast is covered by humus soil and clay and from sediments, and marine deposits.

### 3.1.3 Vegetation

One-third of the Study Area is covered by tropical rain forest which is mainly distributed in the low-lying area along the Navigable Canal.

In the permanent swamps, palm trees (Guaba) and true grasses (Gamolote, Cona, Brava, etc.) of 4 to 5 meters grow profusely.

The vegetation of the semi-humid area adjacent to the permanent swamps is classified into three types: thick-forest area of betel palm trees; forest area of low trees with a height of 5 - 15 m (representative tree; sangrillo, paponjoche, guavas and so on); and forest area of medium-height trees of 20 - 30 m (representative tree: govilan, cativo, caobilla and so on). However, miscellaneous trees of the betel palm prevails in the most of this area.

Cativo, sangrillo and caobilla are useful trees and are brought out to Moin Port through the Navigable Canal.

### 3.1.4 Climate

#### (1) Observations

In the Study Area and its hinterland, the climate and river discharges have been observed by Instituto Meteorologico Nacional (IMN) and Instituto Costarricense de Electricidad (ICE), and there are 30 meteorological stations (see Fig. 3.1.4 and Table 3.1.2) and 18 stream-gauging stations.(see Fig. 3.1.5 and Table 3.1.3)

Among these stations, only three meteorological stations are in the Study Area, and there are no stream-gauging station. Accordingly, there are installed staff gauges at 14 places in the area. Four places have automatic water level recordes and three automatic rain gauges.(see Fig. 3.1.6)

#### (2) Climate

According to the climatical classification by Koppen, the Study Area lies in a tropical rain forest zone. The distribution of annual rainfall, of the whole area including the watersheds of the related rivers, is shown in Fig. 3.1.7. And the annual average rainfall is about 3,700 mm ,but the annual rainfall fluctuates heavily by area, in the range of 1,500 to 7,500 mm, since the watershed areas with extremely value of the rainfall are small. Through a year, dry season does not exist, and a seasonal wind is indistinct.

There are two (2) synoptic meteorological stations with long records at La Lola inside and Limon outside the Study Area. According to the rainfall data recorded at above both stations and three rainfall stations installed for this study, it is appropriate to adopt La Lola as the representative station for the Study Area and the annual rainfall reachs about 3,500 mm on an average.

The general climate condition other than rainfall are as follows;

- Temperature

| | | |
|---|---|---|
| Annual mean temperature | : | 25.0°C |
| Monthly range | : | 24.3°C (Dec.) - 26.1°C (May) |
| Monthly mean maximum | : | Max. 31.1°C (May) |
| Monthly mean minimum | : | Min. 19.6°C (Jan.) |

- Relative Humidity

| | | |
|---|---|---|
| Annual mean relative humidity | : | 84.0% |
| Monthly range | : | 82.0 - 87.0% |

- Sunshine hour

| | | |
|---|---|---|
| Annual mean | : | 1,596 Hr (36.0% of daytime) |
| Monthly range | : | 3.1 hr (Jul.) - 5.3 hr (Mar.) |

- Pan Evaporation (A-type)

| | | |
|---|---|---|
| Annual mean | : | 1,329 mm |

The related details are shown Table 3.1.4 and Fig. 3.1.8.

(3) Rainfall Analysis

The annual rainfall at La Lola meteorological station, which is typical of the Study Area, is 3,500 mm. The monthly distribution over the last 16 years is shown in Table 3.1.5 and Fig. 3.1.8.

There are no distinctive dry periods during the year. Rainfall peaks in July and December (420 mm and 460 mm respectively).

The probable rainfall for short periods and rainfall intensity are

shown in Table 3.1.6.

Table 3.1.6 Probable Rainfall and Rainfall Intensity

| Description | | Probable Rainfall (year) 2 | 5 | 10 |
|---|---|---|---|---|
| Hourly rainfall | mm/hr | 37 | 46 | 51 |
| 1- day max. rainfall | mm/1-day | 155 | 196 | 224 |
| 2- day max. rainfall | mm/2-days | 212 | 282 | 331 |
| 3- day max. rainfall | mm/3-days | 245 | 325 | 382 |
| Rainfall Intensity | mm/hr | 180 / t+3.9 | 229 / t+4.0 | 262 / t+4.1 |

(Note) t: duration of rainfall (hours)

### 3.1.5 Hydrology

#### (1) River

The river network in the related watersheds is characterized as follows:

- The rivers flow to the northeast in parallel to join the Navigable Canal, which runs along the coast. The Navigable Canal catches and regulates runoff coming from the drainage area, and pours runoff into the Caribbean Sea through the river-mouths; thus the Navigable Canal bears the role of flood storage basin for the runoff coming from the drainage area.

- The related section of the Navigable Canal is 46.5 km in length from Boca del Parismina to Puerto Moin, and has four river-mouths, Rio Parismina, Rio Pacuare, Rio Matina and Rio Moin.

- The major portions of large river watersheds are situated in a mountainous region outside the Study Area, while, those of small- and medium-river watersheds are inside the Study Area.

- The entire watershed area of the rivers in the Study Area is 5,648 $km^2$, and is composed of three large river watersheds (D.A.=5,016$km^2$) - Rio Reventazon, Rio Pacuare and Rio Matina - and small-and medium river watersheds (D.A.=632 $km^2$)- Rio Madre de Dios, Rio Blanco and so on, as shown in Table 3.1.7.(see Fig.3.1.9)

Table 3.1.7 Related Watershed Area

| River | Watershed Area ($km^2$) |
|---|---|
| Large River | |
| Rio Reventazon | 2,796 |
| Rio Pacuare | 855 |
| Rio Matina | 1,365 |
| Sub-Total | 5,016 |
| Small and Medium River | |
| Rio Madre de Dios | 189 |
| Rio Blanco | 57 |
| Others | 386 |
| Sub-Total | 632 |
| Total | 5,648 |

The above large rivers originate in the high mountain ranges of Central and Talamanca, which are higher than 3,000 m (above sea level), and have relatively big watersheds. On the other hand, the small and medium rivers rise in the low mountains of about 500 m in altitude and have small basins.

The lengths of the major rivers are as follows:

| | | |
|---|---|---|
| Rio Reventazon | : | 145 km |
| Rio Pacuare | : | 108 km |
| Rio Madre de Dios | : | 37 km |
| Rio Matina | : | 92 km (Main river: 17 km, Rio Chirripo as a tributary: 75 km) |
| Rio Blanco | : | 20 km |

The slopes of the river beds range from 1/25 to 1/60 in the middlestream and upperstream, and after crossing the National Route 32, the slope tapers off to between 1/75 and 1/1000. The description of these watersheds is shown in Table 3.1.8.

(2) Estimation of probable peak flood discharge

The probable peak flood discharge which indicate the runoff condition of rivers are estimated based on the runoff data at four (4) stream-gauging stations which are located at the nearest points to the Study Area as shown in Table 3.1.9.(see Fig. 3.1.9)

Table 3.1.9 Stream Gauging Stations Used for Flood Analysis

| River | Location | Watershed ($km^2$) | Record Length (years) |
|---|---|---|---|
| Rio Reventazon | Pascua | 1,673 | 20 |
| Rio Pacuare | Dos Montanos | 652 | 20 |
| Rio Barbilla | Barbilla | 212 | 8 |
| Rio Blanco | Blanco | 50 | 8 |

Using the annual maximum of recorded peak flood discharge as in Table 3.1.10, the probable specific yield discharges of peak floods are obtained by frequent analysis and shown in Table 3.1.11.

Table 3.1.11 Estimated Probable Specific Yield Discharge

Unit: $m^3/sec/km^2$

| Return Period | Drainage Area ($km^2$) | | | |
|---|---|---|---|---|
| (1/year) | 1673 | 652 | 212 | 50 |
| 2 | 0.836 | 1.288 | 2.124 | 3.450 |
| 5 | 1.402 | 2.193 | 2.866 | 4.772 |
| 10 | 1.850 | 2.791 | 3.370 | 5.652 |
| 20 | 2.333 | 3.374 | 3.867 | 6.498 |

Based on these results, probable specific yield discharge curves are developed (see Fig. 3.1.10) after that, making use of these curves, the probable peak flood discharges of large rivers for a return period and a watershed are estimated as shown in Table 3.1.12.

Table 3.1.12 Probable Peak Flood Discharge

| River | Location | D.A. ($km^2$) | Return Period (year) | Estimated Peak Discharge ($m^3/s$) |
|---|---|---|---|---|
| Reventazon | Railway Bridge | 1,750 | 2 | 1,489 |
| | | | 5 | 2,536 |
| | | | 10 | 3,316 |
| | | | 20 | 4,132 |
| Reventazon | Golden Grove | 1,801 | 2 | 1,515 |
| | | | 5 | 2,585 |
| | | | 10 | 3,383 |
| | | | 20 | 4,220 |
| Parismina | Boca | 2,796 | 2 | 1,968 |
| | | | 5 | 3,460 |
| | | | 10 | 4,596 |
| | | | 20 | 5,801 |
| Pacuare | Railway Bridge | 663 | 2 | 836 |
| | | | 5 | 1,332 |
| | | | 10 | 1,686 |
| | | | 20 | 2,047 |
| | Perla and Boca | 855 | 2 | 973 |
| | | | 5 | 1,577 |
| | | | 10 | 2,013 |
| | | | 20 | 2,461 |
| Barbilla | Confluence with Rio Matina | 259 | 2 | 478 |
| | | | 5 | 714 |
| | | | 10 | 876 |
| | | | 20 | 1,037 |
| Chirripo | Confluence with Rio Matina | 1,108 | 2 | 1,133 |
| | | | 5 | 1,870 |
| | | | 10 | 2,409 |
| | | | 20 | 2,965 |
| Matina | Boca | 1,365 | 2 | 1,284 |
| | | | 5 | 2,151 |
| | | | 10 | 2,789 |
| | | | 20 | 3,452 |

(3) Tidal Sea Level

Though there is no record of tidal sea level in Costa Rica, the sea level of the astronomical tide at Limon Port can be utilized. Since Limon Port is situated on the Atlantic Ocean, and has not been affected so much by hurricanes occuring in the Caribbean Sea, the astronomical tide and actual one can be treated as the same.

From the data on astronomical tide, the following characters have been listed up:

- The maximum tidal range is very slight (about 60 cm).

- The pattern of tidal movement is a diurnal tide for the spring tide and a diurnal inequality for the neap tide.(Fig.3.1.11)

The constant values of the tidal sea level are as follows;

| | | |
|---|---|---|
| Mean high tide in spring tide | : | 0.51 m (m.s.l) |
| Mean high tide in neap tide | : | 0.27 m (m.s.l) |
| Mean tide level | : | 0.15 m (m.s.l) |
| Mean low tide in neap tide | : | 0.00 m (m.s.l) |
| Mean low tide in spring tide | : | -0.09 m (m.s.l) |

(4) Ordinary Water Level of River

The water level of rivers and drainge canals in the low-lying area adjoining the coast is ordinarily affected by the back water of the tidal water level in the Caribbean Sea caused by low river-beds.

According to observation of the water level of the rivers in the low -lying area, as shown in below Table, the water level at a point 6 to 7 km away from the coast is estimated to be about 0.6m (m.s.l).

Table 3.1.13 Ordinary Water Level in River of Low-lying Area

| Description | River | | |
|---|---|---|---|
| | Rio Madre de Dios | | Rio Palacios |
| Station of Staff Gauge | W - No. 6 | W - No. 7 | W - No.13 |
| Distance from River-mouth (km) | 6.2 | 10.8 | 11.0 |
| Distance from Confluence with the Navigable Canal (km) | 2.2 | 6.8 | 4.3 |
| Observed Water Level (m m.s.l) | 0.06 - 0.59 | 0.40 - 0.66 | 0.50 |
| Height of River-bed (m m.s.l) | (-)5.25 | (-)0.06 | - |
| Height of Natural Bank Crest (m m.s.l) | 0.6 | 3.4 | 3.0 |

(5) Present Inundation Analysis

1) Estimation of present flood discharge

The cause of inundation of the Study Area is the lack of discharge capacity of the medium and small rivers,which serve the drainage area of drainage canal, and the drainage canals themselves. Further, in heavy rainfall, the large rivers partially overflow the natural dikes and spread into the above-mentioned drainage area; this aggravates the extent of the inundation. The section most affected by the flooding is the low-lying area including the Navigable Canal. When a big flood occurs, a narrow long lake is formed as a natural flood storage basin along the Navigable Canal for two or three days.

Since actual inundation occurs under the above situation, it is very difficult to directly estimate the present flood discharge concentrating on the natural flood basin. Total volume of a consecutive flood discharge during a long period does not change except in relation to the condition of drainage facilities in the watershed. Thus, the daily mean values of maximum three days' consecutive flood discharge ("project flood") concentrating on the

natural flood storage basin after completion of the project can be regarded as present flood discharge.

In the estimation of project floods, two model watersheds, which are typical of large rivers and of small and medium rivers, are selected. The project floods are estimated by the specific yield discharges obtained from the estimated floods in the model watersheds. The outline of runoff model is as follows;

a) Runoff model of large river watershed

- The watershed of Rio Reventazon is selected as a model. The drainage area at the railway bridge is 1,750 $km^2$.

- The probable hydrographs on an hourly basis are estimated by making use of probable peak flood discharge and maxium of three days' consecutive flood discharge obtained by frequency analysis of recorded data.

- The probable hydrographs at the river-mouth of Rio Reventazon are estimated by a kinematic runoff model. The river length considered in the model is 47 km from the railway bridge to the river-mouth of Rio Reventazon.

b) Runoff model of small and medium river watershed

- A watershed of a principal canal (B-2), with an area of 41.4 $km^2$ is selected.

- The probable hydrograph at the confluence to the Navigable Canal is estimated by a kinematic runoff model and the rainfall at La Lola is adopted.

  The present probable three day's consecutive flood discharges of the whole watershed area of 5,648 $km^2$ are tabulated in Table 3.1.14.

Table 3.1.14 Present Probable Consecutive Flood Discharge

(m3/s)

| | Return period (years) | |
|---|---|---|
| | 5 | 10 |
| 1st Day | 2,125 | 2,996 |
| 2nd Day | 3,602 | 4,876 |
| 3rd Day | 2,567 | 3,032 |

The related details on the flood analysis are shown in Annex B.2.

2) Present inundation analysis

To grasp the extent of the present inundation of the low-lying area along the Navigable Canal, the present inundation analysis was carried out under the following conditions:

- Taking account of the actual inundation condition, it is considered that the flood of the whole watershed is concentrated in the low-lying area and made one continuous inundation area along the coastline.

- The outflow from the inundation area is made through four (4) river-mouths of Rio Parismina, Rio Pacuare, Rio Matina and Rio Moin. These discharge capacities are estimated according to the river sections at the river-mouths.

The present inundation analysis has been made for the floods with the probability of 5-year and 10-year return periods. The estimated inundation conditions are shown in Table 3.1.15.(see Fig. 3.1.12)

Table 3.1.15 Present Inundation Condition

| Return Period (Year) | Max. Ponding W.L. (EL. m) | Duration of*/ Inundation (hr) | Max. Inundation Area | |
|---|---|---|---|---|
| | | | Study Area (ha) | Whole Area (ha) |
| 5 | 1.22 | 13 | 1,619 | 5,052 |
| 10 | 1.45 | 32 | 3,312 | 7,042 |

*/ Lasting duration with the ponding water level of more than 1.0 m (m.s.l).

More details on the inundation analysis are shown in Annex B.3 together with the inundation analysis for the case of completion of project drainage facilities.

(6) Analysis of Well-Water Quality

In order to prove whether the quality of well-water in the Study Area is suitable or not for drinking use, well-water was sampled at 10 places (see Table 3.1.16) six of them are shallow wells and four are deep wells. The depths of the wells range from 3 to 6 m for the shallow ones and from 30 to 60 m for the deep ones.

According to the analyzed results, only three deep wells(No.3, 4 and 5)among these ten places are suitable as a water resource of drinking, but the other wells are not suitable as they have substantial coliform bacteria, so that the water will have to be sterilized by boiling if it is used for drinking.(see Table 3.1.17)

### 3.1.6 Soil

#### (1) General

Based on a reconnaisance survey and collected data, the survey was conducted by the observations on the profiles in 26 pits selected and the distribution of the soil groups was checked by hand-auger. (see Fig.3.1.13) Also, the three phases of soil were measured to estimate the contents of moisture and air in the soils after drainage.

Most soils in the Study Area are formed from alluvial deposits transported by many rivers such as the Rio Reventazon, Rio Chiguero, Rio Pacuare, Rio Madre de Dios, Rio Matina, Rio Chirripo and Rio Toro, flowing from the Talamanca Mountain range located in the south-west. Some of the deposits contain much limestone and volcanic materials such as volcanic ash. Most of the deposites are new parent material of alluvial epoch.

The land undulates over this fan and the neighboring alluvial area, with a gradient of less than $10^{o}$: it is mostly a plain sloping slightly from the southwest hills toward to the northeast coast. In this plain there are many natural dikes along the main rivers, having several meters higher than the low-lying area.

Of the many soil genetic factors, the excess water in the soil caused by poor drainage and shallow groundwater table have a major affect upon the soil genesis. Most of the soils are classified into the "youngest soil" and the "underdeveloped soil" in the soil taxonomy.

Generally speaking, most of the soils in the Area have favorable chemical properties, and few physical hindrances to the growth of plant roots in the sublayers, and the favorable characters of the soils for crop production would be covered due to the year round excess water.

(2) Soil Classification

The classification of soils in the Study Area which was made by MAG, based on the USDA soil taxonomy method, was checked by the Team, (see Table 3.1.18), and the distribution of subgroups is shown in Fig. 3.1.13.

As shown in the table, Entisol, the latest formed youngest soil, occupies 29% of the Area. The Entisol is subdivided into Typic Tropaguent (E-1) and Troporthent (E-4), and the E-1 is distributed on the low land near the coast and the E-4 on the higher land near the south-west boundary along the National Route 32. For agricultural use, the E-1 has more problems and severer limitations than the E-4.

Inceptisol, occupies 70% of the Area, is classified into Aeric Tropaquept (I-16) and Tropaquept (I-2). The I-16 group occupies about 28% of the Area and is developed mainly on the natural dike along the rivers. The soil layer is generally oxidated, and the groundwater level is low , so this soil would be suitable to the cultivation of common upland crops. The I-2 group occupies about 41% of the Area is distributed in lowland on the back of the dike. The soil is in shallow groundwater level, imperfect drainage, and a reductive status, and the gley horizon can be seen from a ground surface in some places. Thus this soil will be unfavorable to crop except for hydrophyte and some kinds of plants with a nature of wetproof due to the high content of soil water.

Ultisol occupies only 1.4% of the area, distributed on the alluvial fan derived from the alluvial deposits; it has strong acidic properties and is stony, and would be problematic for agricultural use.

Histosol, occupies only 0.9% of the area is didtributed on the lowest places of the lowland; it has extremely poor drainage being developed from the abundant decayed organic matter such as peat, and can not be used for agriculture.

The above-mentioned soils in each subgroup could be classified into some subgroups, based on their texture, stratification, quality of the deposits especially the mix of volcanic ash or limestone, base status and micronutrient content, etc.. The outline of chemical and physical characteristics of the each subgroup are described below.

(3) Chemical Properties

Generally, the most of the soils in the Area are rich in exchangeable cations, such as Ca, Mg and K, and the degrees of the base saturation as well as the cation exchange capacities are high. However, the fact that Ca, Mg and K in many soils are unbalanced, suggests the possibility of potassium deficiency for some plants.

As to the plant nutirion supply, the following points should be noted. Since the soil with much volcanic ash tends to the lack of the available phosphorus, the supplement of phosphorus is important. Furthermore, the soil does not have enough organic nitrogen, so the loss of nitrogen would occur rather easily. Thus, adequate dressing of these elements seems to play an important role especially for these soils. In microelements, zinc deficiency would be the most important problem. The deficiency would occur rather easily according to the kind of parent materials. Also, the possibility of iron deficiency for rice would be rather high in sandy soils (see Annex C Table C.4.1 - C.4.4).

(4) Physical Properties

Although the layers with hard pans of gravel or clay pose a severe obstacle to root growth were not observed in a depth of one meter from the ground surface, most of the soil layers are hard, in spite of the high moisture of soil body all the year round. This may result from the strong combination of particles in the soils due to the richness of exchangeable calcium. So that, the soil layers could support the growth of big trees and some heavy construction.

The distribution of the three phases of soil (solid, liquid and air) after excluding the gravitational water, namely under the field capacity moisture, was measured from the core-samples taken from the soil profiles in the field. A part of the summarized data are presented. (see Table 3.1.19) From the data it is found that the soil groups of I-16, having good drainage, have 56% in liquid phase, 5.8% in air phase, 54% in moisture ratio (by weight) and 1.06 in apparent density, while these values of the I-2 groups which have imperfect drainage, are 61%, 4.7%, 67% and 0.94 respectively.

Thus, the latter group has more micro-fine pores, higher water holding capacity and lower air phase percentage than the former group.

The soil materials having the apparent density lower than 0.85 are defined as the volcanic ash soil in the soil taxonomy, and the surface soils of the pits of No.15, 27, 2 and 17 seem to have much the volcanic ash, They have apparent density of 0.75 on an average, and have fairly high water holding capacity as much as about 90% in the water rate. Therefore in the case of soils mixed with the much volcanic ash, the rain water causing reductive condition, seems likely to pond in the surface layer, with weak gray color.(see Annex C Table C.3.1 - C.3.6)

(5) Land use for agriculture from the viewpoint of soil science

Based on the characteristics of the above-mentioned soils, some considerations on the land use for agriculture in the area are described briefly.

1) Land improvement

The arrangement of facilities to control flood and artificial drainge canal to exclude the excess water in the soil body seem to be essential for the development of advanced agriculture in the Area, especially for the depression land with the E-1 and I-2 soil

groups. Furthermore, in the area of the soil with the air phase of less then 5.0% even under the field capacity, the dranage ditches with the depth of about 1 m would be installed in closer density than for the other area having a soil with the air phase of more than 5.0%.

Introducing green manure plants with deep roots in cropping systems should be achieved for the development of macro pores in subsoils, contributing to the drainage.

2) Soil management

The effects of drainage would be exclusion of excess water in soils and also oxidation of soil materials.

Under the given climate of the area, the high temperature and heavy rain, the decay of soil organic matter and losses of plant nutrients through leaching, would be likely to occur rather rapidly, so that adequate soil management to suit the changes in the soil conditions caused by the drainage improvement would be very important for the high and stable production of crops.

The countermeasures in soil management would be considered as follow; In the first several years after the implementation of the drainage facilities, the soil organic matter will decompose violently and will supply lots of N, P, K and other nutrients to plants accompanying the decrease of soil moisture. In some cases, excess nitrogen may cause plant disease. Thus, much attention has to be paid to adequate dressing of nitrogen and pest control during this stage.

In the several years after the early stage, the vigorous decomposition of the soil organic matter will subside, decreasing the natural supplying power of nutrients from the soil remarkably decay, then, both the dressing of fertilizer including minor

elements and soil amelioration will become more important for intensive farming, and for the land where is blocked the supply of limestone by a flood protection work, the supplement will be needed.

Dressing of chemical fertilizer seems to hasten the leaching and acidification of the soil, and the intensive farming removes many elements from the field soil. As a result, the soil will be made unbalance of the nutrients. Accordingly, since green manure crops with deep roots take up the nutrients in subsoils, the introducing these crops in field would contribute to the maintaining of soil fertility.

### 3.1.7 Land Classification

Based on the soil survey, the land classification has been made considering various limiting factors. The greatest limiting factor to the land classification is soil moisture. The other factors, such as climate, gradient of land, erodibility and soil fertility are not important as limiting factors for the land classification, and the salinity and alkalinity of the soil in the Area also are not affected to the farming.

Thus, as the key factors to limit the land use in the Area, the following items were selected, such as natural drainage, groundwater level, extent of inundation, depth of effective soil layer, texture of top and subsoil and stony status of land surface and subsoil.

The land use classification obtained, based on the above consideration and the USDA method, is indicated in Table 3.1.20, and distribution map in Fig. 3.1.14. The specifications for the classification are shown in Tables 3.1.21.

Class I : There is no pertinent area in the Study Area.

Class II: The peritient area consisting of the I-16 and E-4 soil groups mainly, occupies 34% of the Area, and has deep

groundwater level, good drainage and rather slight extent of inundation. It could be utilized for cultivation of many kinds of crops. Although artificial drainage by drains would be desirable in some cases, the necessity in this area is relativily low in comparison with that of the other area ranked in lower classes.

Class III: The pertinent area is covered by the I-16 and E-4 soil groups within less favorable drainage conditions than Class II and the I-2 soil group in the relatively higher land, and occupies about 22% of the Area. On the groundwater table, drainage condition and the extent of inundation, the Class III is inferior to the Class II, but it is well to the Class IV, and this area could be utilized for many kind of crops with adequate artificial drainage facilities.

Class IV : The pertinent area, corresponding to most of the I-2 soil groups, is distributed on the relatively lower land of 4 to 8 m elevation, and occupies about 19% of the Area. Having rather shallow groundwater level, imperfect drainage and severe flooding damage, it could be utilized only for crops with strong resistance to the wet, such as rice and some species of pasture grasses and trees. Artificial drainage would be essential not only for reasonable yield of the crops but also for work efficiency and movement of tractors and grazing cattle. However, the cultivation of upland crops would not be favorable in general, because some of the land has a very high volcanic ash content, and is very moist even after gravitational water is removed by artificial drainage.

Class V : There is no area corresponding to this class.

Class VI : This land corresponds to all the U-1 soil group, and occupies only about 3% of the area. It has good drainage, deep groundwater level and no danger of inundation, is of strong acidity in the soil and stony above and below the surface, and could be utilized only for perennial crops such as pasture grasses, fruit-trees and forestry,because the stone land makes planting of annual crops difficult.

Class VII : This area corresponds to a part of the E-1 soil group. It is located on the relatively higher land at some distance from the coast. At nearly 4 m above sea level it has worse drainage and inundation damage than the Class IV & V. Occupying 6% of the Area, it is suitable for grassland and forest.

Class VIII: The area corresponds to most of the E-1 soil group near the coast, with an elevation of under about 4 m, and to all of the H-1 soil group, is located in the depressions with very low elevation. Both soil groups occupy about 15% of the Area as a whole, have very poor drainage and extreme inundation damage, so this Area should be reserved as a natural forest.

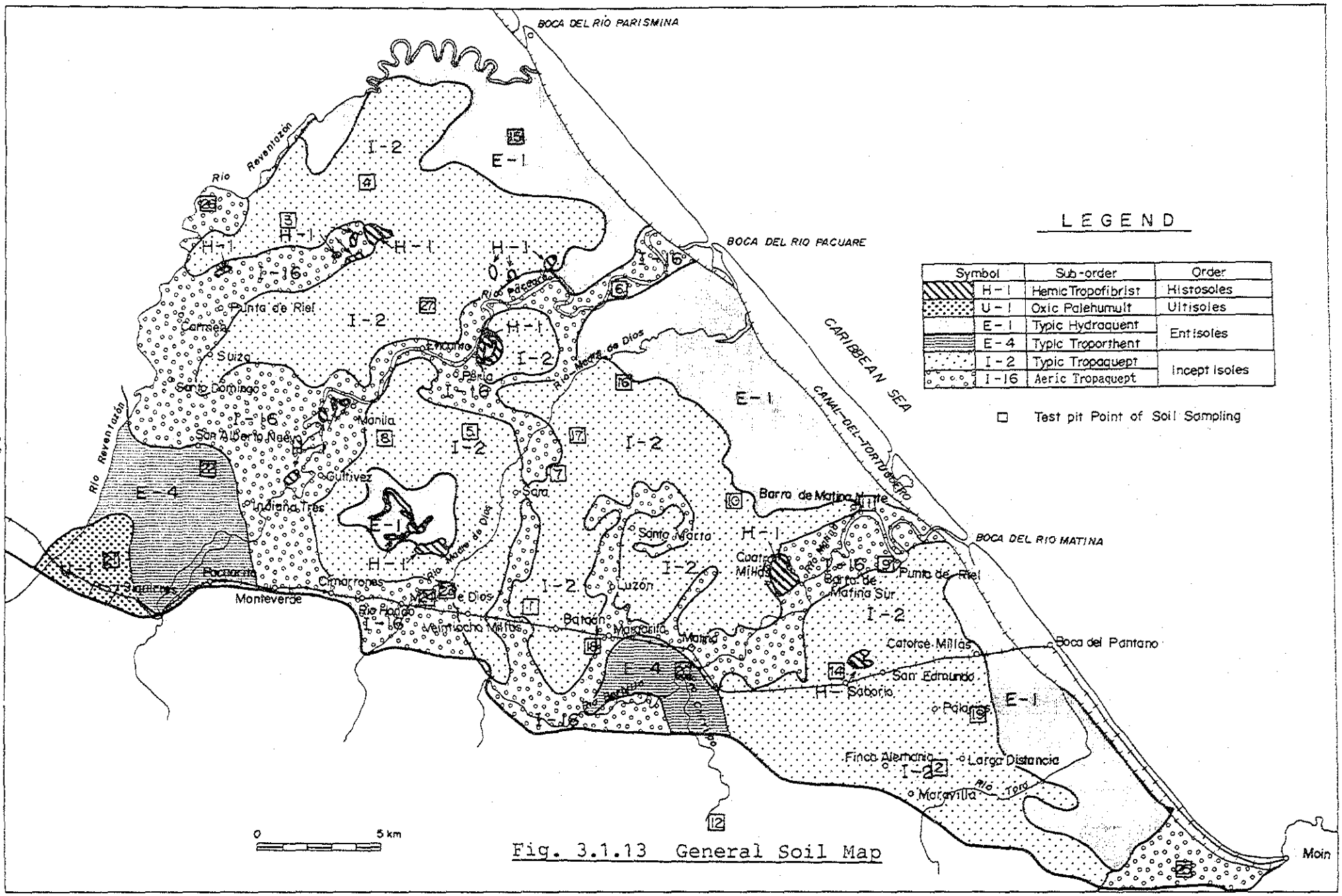



Fig. 3.1.13 General Soil Map

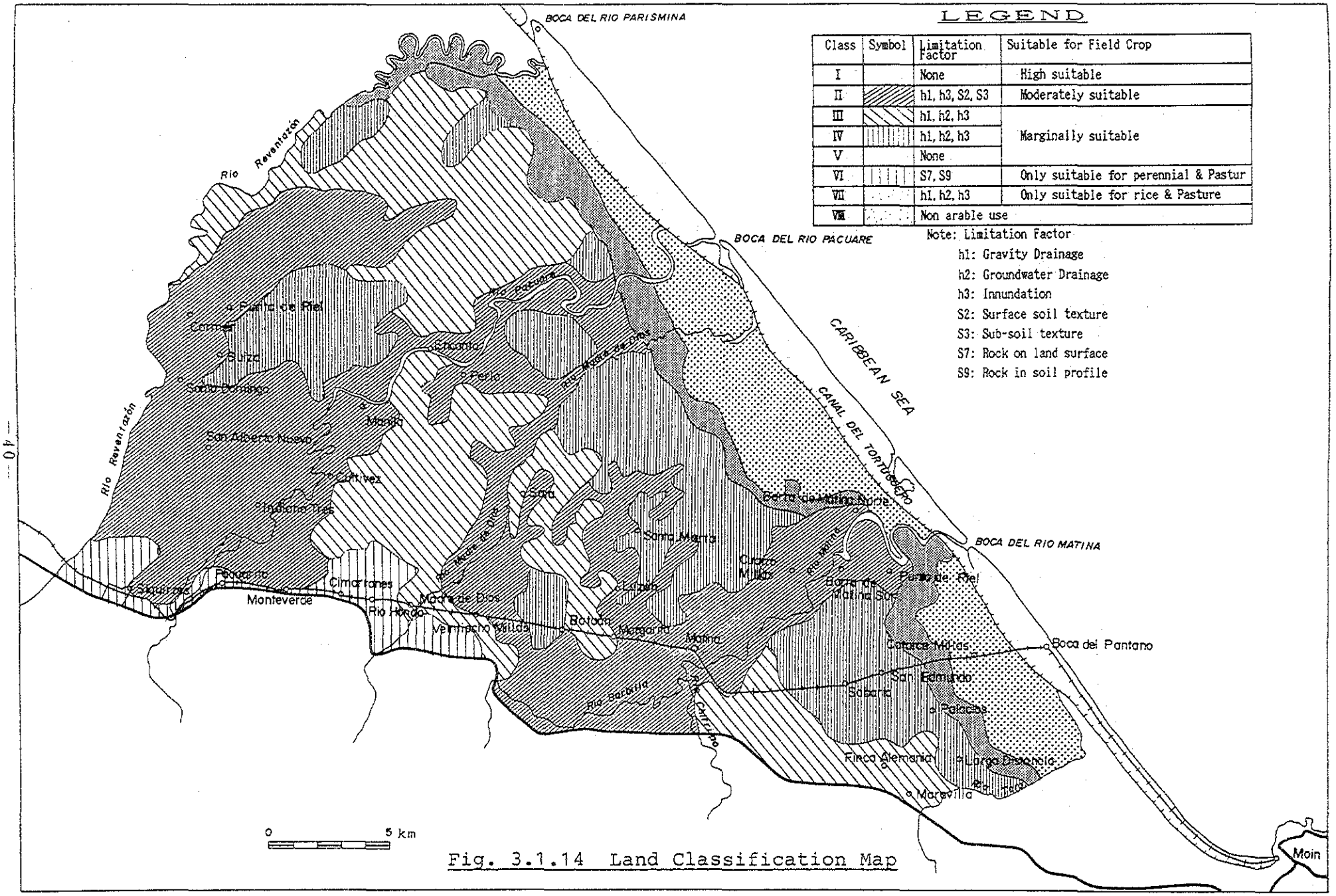



Fig. 3.1.14 Land Classification Map

## 3.2 Socio-Economic Conditions

### 3.2.1 Administrative Organization

The Study Area is located in the central area of Limon Province and belongs to the Cantons of Siquirres and Matina. In these cantons, the districts as subordinate administrative units are as follows:

Table 3.2.1 Administrative Unit in Study Area

| Province | Canton | District | Area ($Km^2$) | Location of Municipal Office |
|---|---|---|---|---|
| Limon | Siquirres | Siquirres | 218.03 | Siquirres |
| | | Pacuarito | 373.25 | |
| | Matina | Matina | 354.37 | Matina |
| | | Bataan | 213.26 | |
| | | Carrandi | 205.01 | |

Administrative boundaries of these cantons and districts are shown in Fig. 3.1.1.(Administrative area map)

### 3.2.2 Population

According to the 1984 Census, total population in Limon Province is 168,076 habitants, about 7% of the total population of Costa Rica.

Population distribution in urban and rural areas is as shown in Table 3.2.2; the rural population accounts for about 70%.

Table 3.2.2 Population in Study Area

| | Urban (hab.) | Rural (hab.) | Total (hab.) | No.of Family | Density (hab./km²) | Estimated Population in the study area | Zone |
|---|---|---|---|---|---|---|---|
| Limon | 50,797 | 117,279 | 168,076 | 37,530 | 18 | | |
| Siquirres | 7,146 | 21,933 | 29,079 | 6,339 | 34 | | |
| *Siquirres* | 7,146 | 10,376 | 17,522 | 3,872 | 47 | 7,290 | D |
| Pacuarito | - | 4,357 | 4,357 | 937 | 20 | 2,070 | C |
| Matina | 1,102 | 13,621 | 14,723 | 3,275 | 19 | | |
| *Matina* | 1,102 | 2,862 | 3,964 | 872 | 11 | 8,200 | B |
| Battan | - | 6,712 | 6,712 | 1,463 | 31 | | |
| Carrandi | - | 4,047 | 4,047 | 940 | 20 | 2,300 | A |

Source: Census 1984

Cantons and districts in the Study Area are almost all rural areas excepting for the District of Siquirres, which includes an urban area.

The ratio of population in the rural area is 78% over the average of Limon Province, and the relative density is about 20 hab./km$^2$ on an average.

Table 3.2.3 Movement of Population in the Study Area

| Canton | Movement of Population | | Ratio of Population(%) | |
|---|---|---|---|---|
| | 1968~1973 | 1973~1984 | 1968~1973 | 1973~1984 |
| Siquirres | + 1,647 | + 5,488 | + 9.08 | + 18.15 |
| Matina | + 1,313 | + 684 | + 12.52 | + 4.47 |

Source:Dynamic Stastics of Population 1973-1984,MIDEPLAN

From the Census, there are estimated 4.5 persons per family in the Study Area.

The population of economic activities in the Study Area is 11,609 persons, as shown in Table 3.2.4 and 3.2.5, and about 68% of the working population is engaged in agriculture, forestry and fisheries (except for the unemployed).

### 3.2.3 Agricultural Economic Activities

The population in the Study Area is spread over the main towns and some settlements of IDA.

The three towns, Siquirres, Bataan and Matina, attract many people from the surrounding countryside, and these towns play the part of an important market. The settlements of IDA are spread in the northern part of the Study Area and low-land area to the coast. Many settlers have been relocated several times because of poor drainage, lack of farming funds and agricultural machinery and equipment.

Definition of boundaries in terms of marketing and economic activities in the Study Area does not exist. However, agriculture supporting organizations perform the extension activities on the provincial level or canton unit. The agricultural economy in the Study Area is only active in the banana industry.

Farming in the Area is generally inactive except for banana production, and there are few other agricultural industries or marketing facilities.

There are some marketing facilities such as a rice mill (capacity: 36.0 quintal/hr) and rice storehouse (storage capacity: 6,000 t) in Bataan which collect unhulled rice from 150 farmers; two cocoa bean collectors who purchase about 20 tons /week of dry beans on an average; an exporter of tuber crop in Siquirres; and a chip processing factory of plantain, tuber crop (tiquisque) and cassava which produces only for export.

## 3.3 Land Use

### 3.3.1 Actual Land Use

In order to grasp how the Study Area for about 67,000 ha is being utilized, the size has been measured for every land category by a survey in the field, based on the map reduced to a scale of 1/50,000 and by aerial photographs taken in March, 1987. These are shown in Table 3.3.1. (see Fig.3.3.1)

Table 3.3.1 Present Land Use

| Classification | Zone A | Zone B | Zone C | Zone D | Total |
|---|---|---|---|---|---|
| Annual Crop Land | | | | | |
| Rice | 1,580 | 2,890 | 200 | 440 | 5,110 |
| Kidney Bean | 20 | 43 | 21 | 48 | 132 |
| Maize | 163 | 349 | 370 | 820 | 1,702 |
| Fallow Land etc. | 327 | 1,188 | 679 | 4,082 | 6,276 |
| Sub-total | 2,090 | 4,470 | 1,270 | 5,390 | 13,220 |
| Perennial Crop Land | | | | | |
| Banana | 1,100 | 1,870 | 1,810 | 2,860 | 7,640 |
| Cacao | 1,884 | 1,412 | 934 | 2,092 | 6,322 |
| Fallow Land etc. | 56 | 258 | 176 | 228 | 718 |
| Sub-total | 3,040 | 3,540 | 2,920 | 5,180 | 14,680 |
| Pasture | 2,480 | 3,150 | 3,250 | 5,700 | 14,580 |
| Sub-total | 2,480 | 3,150 | 3,250 | 5,700 | 14,580 |
| Forest | | | | | |
| Virgin Forest | 2,150 | 3,220 | 740 | 5,120 | 11,230 |
| General Forest | | 2,500 | 2,660 | 1,040 | 6,200 |
| Secondary Forest | 640 | 1,540 | 660 | 550 | 3,390 |
| Sub-total | 2,790 | 7,260 | 4,060 | 6,710 | 20,820 |
| Others | 400 | 1,080 | 1,100 | 1,120 | 3,700 |
| Sub-total | 400 | 1,080 | 1,100 | 1,120 | 3,700 |
| Total | 10,800 | 19,500 | 12,680 | 24,100 | 67,000 |

The result is that perennial agricultural lands occupy 14,680 ha (about 22%) exceeding the annual crop lands of 13,220 ha (about 20%). The latter has been left without cultivation and mostly has changed into grassland. The former is planted, but almost none is well-conditioned. In case cacao grows ripe, farmers just go and gather them, as is often the case with farms.

Poor drainage, shortage of farming funds, advanced age of trees and occurrence of disease and insect pests are mentioned as the causes.

The whole area of agricultural land is 42,480 ha (14,680 ha for perennial crops, 13,220 ha for annual crops and 14,580 ha for pasture), details of which are as follows:

Table 3.3.2 Agricultural Land Area

(ha)

| Zone | Perennial Crop Land | Annual Crop Land | Fallow Land of annual crop | Pasture | Total |
|---|---|---|---|---|---|
| A | 3,040 | 1,830 | 260 | 2,480 | 7,610 |
| B | 3,540 | 3,520 | 950 | 3,150 | 11,160 |
| C | 2,920 | 920 | 350 | 3,250 | 7,440 |
| D | 5,180 | 2,040 | 3,350 | 5,700 | 16,270 |
| Total | 14,680 | 8,310 | 4,910 | 14,580 | 42,480 |

Grassland occupies about 22% for 14,580 ha where cattles are grazed. However, pasture is not planted but there is agricultural land left to turn into grassland. Otherwise, cut-over land has been changed to grassland.

Forest occupies about 31% for 20,820 ha. Especially, in the low-lying area along the Navigable Canal virgin forest occupies 10,000 ha, namely about 15% of the whole area. From the view point of environmental conservation, cutting of the forests is limited. As they are in low and swamp land it will be difficult to develop them as agricultural land.

### 3.3.2 Situation of Land Tenure and Holding

The situation of land tenure and holding in the Study Area is as follows:

Table 3.3.3 Classification of Land Tenure and Holding

(ha)

| Classification / Zone | Private Land | | | | National Land | Urban District | Total |
|---|---|---|---|---|---|---|---|
| | IDA's Settlement | Banana Plantation | Others | Sub-Total | | | |
| A | 3,560 | 1,100 | 4,900 | 9,560 | 840 | 400 | 10,800 |
| B | 9,930 | 1,870 | 6,160 | 17,960 | 1,040 | 500 | 19,500 |
| C | 1,310 | 1,810 | 5,970 | 9,090 | 2,810 | 700 | 12,600 |
| D | 4,000 | 2,860 | 7,910 | 14,770 | 8,430 | 900 | 24,100 |
| Total | 18,800 | 7,640 | 24,940 | 51,380 | 13,120 | 2,500 | 67,000 |

Sources : Data of IDA and JAPDEVA

Classification between national and private land is as shown in Fig. 3.3.2.

## 3.4 Agriculture

### 3.4.1 General

Agricultural activity in the Study Area was developed by banana plantations from the 1880s; the cultivation of other perennial crops such as cacao and plantain began after that. At present the Study Area is located in the country's main production area of the perennial crops for export.

The present cropping area is estimated to be 16,548 ha, of which approximately 50% is for annual crops and approximately 50% for perennial crops. The major crops in the Study Area are the perennial crops mentioned above and annual crops such as rice, maize, kidney beans and tuber crops such as yam and taro. Annual crops except rice and tuber crops are produced for the farmers' own consumption. Agricultural crops excluding bananas in the Study Area are mainly produced by small- and medium-scale farmers.

At present, frequent flooding and insufficient drainage are the major agricultural obstacles to increasing the agricultural production in the Study Area. In particular, these conditions affect the small-scale farmers on the improvement of productivity and increase the cropping area. There are many small-scale farmers in accordance with the IDA's settlement policy, and urgent measures are expected for those small-scale farmers.

### 3.4.2 Farming Pattern

#### (1) Number of farm household and farm scale

The number of farm household and farm scale in the Study Area were calculated mainly based on IDA's settlement register (1986).

According to the classification of farm scale defined by IDA and RUTA (Proyecto de Desarrollo Agricola en la Zona Atlantica, 1984), a

small-scale farmer's land holding area is less than 12 ha. A medium scale farmer's land holding area is 12 to 40 ha and larger land holding farmer is a large-scale farmer. The IDA's standard of average area for sale in lot per settlement farmer is 10 ha.

The number of farm household and the average land holding by zone is shown in Table 3.4.1. The breakdown of zone-wise distribution of farm scale is summarized in Annex E Table E.2.1. The total number of farmers excluding the large-scale banana plantation owners in the Study Area is 4,416 and the average land holding per farmer is 9.1 ha. The number of small-scale farmers owning less than 12.0 ha is about 72% of the total number of farmers, and about 50% of the small scale farmers are distributed in Zone B.

Table 3.4.1 Number of farm household and average land holdings

| Zone | Number of farm household | Average land holding area (ha) |
|---|---|---|
| A | 514 | 15.7 |
| B | 1,822 | 8.2 |
| C | 461 | 13.4 |
| D | 1,619 | 6.7 |
| Total | 4,416 | 9.1 |

(2) Farming Pattern

The farm management type and cultivated crops in the Study Area vary according to the scale of the land holding.

Generally, for the medium-scale farmers, the main farming pattern is monoculture of rice or cacao. Large scale farmers engage in rice farming, and large-scale cattle ranchers exist in Zone A and Zone D.

Among the small-scale farmers, farmers owning over 5.0 ha of cropping area devoted to the monoculture of cacao or rice, cattle-

breeding also prevails. On the other hand, farmers having less than 5.0 ha of cropping area multiple the farming of perennial crops such as coconut and plantain. The majority of the small-scale farmers cannot cover living expenses with only agricultural incomes and thus have become part-time farm householders.

Bananas are planted in a large scale monoculture system by foreign and domestic companies and cooperatives. The cooperatives, composed of 30 to 50 association farmers, have average holding areas of 250 to 300 ha. The actual cropping area of bananas is about 60 to 70% of the land holding area; the remaining area is utilized for the processing factory, living quarters, cable way and drainage facilities.

The general farming pattern in the Study Area is shown in Table 3.4.2.

Table 3.4.2 General Farming Pattern

| Cropped Area(ha) | Farming Pattern | Crops |
|---|---|---|
| less 5.0 | Multiple of perennial crops | coconuts + plantain |
| 5.0 - 12.0 | Monoculture of perennial crops | cacao |
| | Multiple of annual crops | rice, maize, tuber, kidney beans |
| | Livestock | cattle |
| 12.0 - 40.0 | Monoculture of perennial crops | cacao |
| | Monoculture of annual crops | rice |
| more than 40.0 | Monoculture of perennial crops | banana |
| | Monoculture of annual crops | rice |
| | Livestock | cattle |

### 3.4.3 Agricultural Production

The following is the present situation of major crops in the Study Area.

#### (1) Cropped area

As indicated by the present land use, the agricultural land area is 42,480 ha. The agricultural land is divided into perennial crop land, annual crop field land, pasture land and fallow land. Most of the pasture land is natural pasture. Fallow land consists of annual crop fields, but this varies year by year.

As shown in the Table 3.4.3, the total cropping area, excluding the pasture and fallow land, is 16,548 ha, of which 50% is used for perennial crops such as bananas and cacao.

The cropping area of rice covers about 31% of the total cropping area. The figures for cropping areas were obtained from calculating the agricultural production data in the cantons of Siquirres and Matina prepared by MAG. In reference to the result by calculating of cropping area, as shown in the Table 3.4.4, the cropping intensity in the Study Area is estimated to be 36.0%.

Table 3.4.3 Present Cropped Area

unit : ha

| Crops / Zone | Perennial | | | | sub-total | Annual | | | | sub-total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Banana | Cacao | Coconut | Plantain | | Rice | Maize | Kidney Bean | Tuber | | |
| A | 456 | 450 | 30 | 26 | 962 | 1,580 | 163 | 20 | 67 | 1,830 | 2,792 |
| B | 904 | 1,390 | 130 | 128 | 2,552 | 2,890 | 349 | 43 | 238 | 3,520 | 6,072 |
| C | 1,088 | 660 | 90 | 86 | 1,924 | 280 | 370 | 21 | 329 | 920 | 2,844 |
| D | 1,712 | 860 | 120 | 108 | 2,800 | 440 | 820 | 48 | 732 | 2,040 | 4,840 |
| Total | 4,160 | 3,360 | 370 | 348 | 8,238 | 5,110 | 1,702 | 132 | 1,366 | 8,310 | 16,548 |
| (%) | 25.1 | 20.4 | 2.2 | 2.1 | 49.8 | 30.9 | 10.3 | 0.7 | 8.3 | 50.2 | 100.0 |

Table 3.4.4 Cropping Intensity

| Zone | Agricultural Land Area (ha) | Cropped Area (ha) | Cropping Intensity (%) |
|---|---|---|---|
| A | 6,510 | 2,336 | 36.0 |
| B | 9,290 | 5,168 | 56.0 |
| C | 5,630 | 1,756 | 31.0 |
| D | 13,410 | 3,128 | 23.0 |
| Total | 34,840 | 12,388 | 36.0 |

Remark: Banana Plantations are excluded from cropping and agricultural land area.

(2) Cropping Pattern

The present cropping pattern for the major crops in the Study Area is shown in Fig. 3.4.1.

The Study Area has high temperature and much rain all year round, therefore, there is no clear distinction between the rainy and dry seasons. However, for the annual crops, the period from May to November with heavier rain is defined as the first cultivating season and the period from December to April, the second.

For the upland field rice, double cropping by direct sowing method is permeated in the Study Area. Generally, for the first cultivating season, sowing is done in mid-April, and the harvesting in September, for the second, sowing is in mid-October and harvesting in March. There is no rotation of crops. It is either monoculture of rice or continuous cropping. According to the farm management survey, rice cropping is no injury by continuous cropping because of appropriately inundated condition and small-scale farmers let their rice farmland lie fallow every 3 to 5 years.

Double cropping of other annual crops such as maize and kidney beans is possible but single cropping is common in the Study Area. Sowing

density of the seed per ha is not different from MAG's recommended sowing density, but the yield is very low because of flooding and insufficient drainage.

Area planted by the settlement farmers, tuber crops such as taro and yam have been increasing in recent years. The cultivation season for the tuber crops is the same for rice, but the growing period is moderately long, therefore, a single cropping is adopted.

Plowing, sowing and harvesting for rice depend on agricultural machinery, while other annual crops depend on man-power only.

The following shows the main varieties of major crops and sowing density per ha. Guaranteed seeds prepared by C.N.P are used.

Table 3.4.5 Main Variety and Sowing Density

| | Crops | Variety | Sowing Density (kg/ha) | MAG's Recommend Sowing Density (kg/ha) |
|---|---|---|---|---|
| 1 | Rice | C.R. 1113 | 100 - 150 | 150 - 200 |
| 2 | Maize | Tico V-7 | 18 - 25 | 20 - 28 |
| 3 | Kidney Beans | Mexico 80 (rojo) | 30 - 50 | 50 - 60 |
| 4 | Taro | Xantosoma Violanceo | 950 - 1,100 | 1,200 - 1,500 |

Source: (1) AGROTECNICO, C.N.P, 1986
(2) Informacion basica del sector agropecuario de C.R.2, 1986
(3) Farm Management Survey, 1987

Bananas are cultivated continuously for an average of 10 to 15 years because the ratooning method is utilized. Bananas can be harvested from the second year. Yield drops in the tenth year usually, so new planting is done every ten or thirteen years. According to information of ASBANA, intercropping with other perennial crops has

not spread because monoculture is in general regarded as highly productivity. The major varieties used are hybrid seeds of Grand Naie and Cavendish, and cropping density in generally 3.0 x 3.0 m per ha.

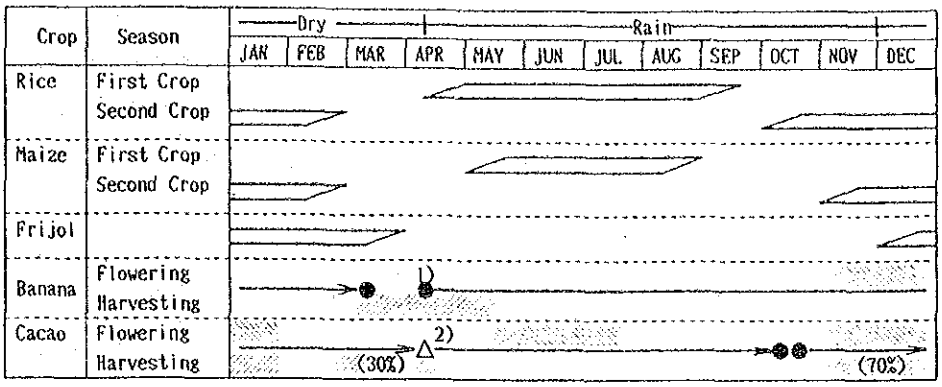
Banana cultivation is based on the plantation system; the groundwater table for banana is lowered to 1.5 - 2.0 m regularly by the maintenance of drainage, and high productivity is maintained. At present, the prevention of Sigatoka - Negra diseases is a problem; agricultural chemicals like Bordo liquid are being applied to prevent this diseases.

The period from planting to harvesting is about two-and-a half to three years for cacao, and the production continues from twenty five to thirty years normally. Intercropping with perennial crop like the pulse family and true grasses, is being extended.

Cacao growing in the Area is mainly engaged by small-scale farmers because one person is able to manage by himself a cacao farm of 6.0 to 7.0 ha. However, frequent flood and poor drainage has affected their farming because of insufficient drainage facilities. There are also frequent outbreaks of diseases such as Monilia and Mazorca Negra.

By improving the drainage and applying chemicals, it is possible to reduce the percentage of outbreaks of diseases to less than 8.0% (La Lola Experimental Station of CATIE).

Major varieties extended are hybrid seeds of UF 296 x CC-18, UF 613 x IMC-67, etc., which are recommended by MAG and CATIE. Cropping density of cacao is generally 3.0 x 3.0m, 1,111 units per ha.




Note : 1) ●→● Sowing & Growing Period (11 months)
2) ●→△ Sowing & Planting Period ( 5 months)
△→● Planting & Growing Period (3 months)
( ) % of production volume per year

Fig. 3.4.1 Present Cropping Pattern

(3) Yield and Production

The following is the present situation of yield and production of major crops in the Study Area.

Yield and production of major crops to compare with the Atlantic region and country level are shown in Tables 3.4.6 and 3.4.7, respectively.

1) Bananas

Bananas are produced at the rate of 240,000 tons in the Cantons of Siquirres and Matina, and 80% of production is in the Study Area. Average yield in Matina and Bataan is 43.3 tons/ha., equal to the national average. In Siquirres it is 47.5 tons/ha. which exceeds the national average. The total banana planted area in the country is about 20,000 ha and total production is about 880,000 tons (1986).

There was about 25,000 ha. of banana planted area in 1984, but in 1985, about 4,200 ha was abandoned because of the withdrawal of foreign companies in the South Pacific and the North Atlantic Regions. Some of the reasons for the withdrawal of foreign companies are the increase in production cost and labor conflicts.

The Government of Costa Rica plans to increase the total amount of banana production to 1,100,000 tons by 1990. The following points have been proposed for the purpose:

- To expand the newly planted area by 8,000 to 10,000 ha.
- To rehabilitate and reutilize abandoned farms.
- To increase productivity.
- To increase production by national companies and cooperatives.
- To develop and promote "Mini Finca" (small-scale farms).

2) Cacao

Total cacao production in the Study Area is 1,176 tons, equivalent to about 30% of the national production. According to the farm management survey the average annual cacao yield is 0.28 to 0.35 tons/ha; however, there are differences in yield depending on the drainage conditions and cultivation techniques in each zone. Those farmers who have relatively good drainage conditions and who receive extension service from MAG have records of 0.5 tons/ha. The Cacao Experimental Station (La Lola, CATIE), located in the Study Area, sells a hybrid variety with a record of an average yield of 1.5 tons/ha as a guaranteed seed to the farmers.

The total national cacao production is about 3,800 ton (1986) and it has decreased each year from about 10,000 ton in 1972. Even though Costa Rica used to export cacao, it is importing about 500 or 700 tons annually at present. The cacao processing factories in the country have an operation ratio of about 50% due to lack of raw materials.

The direct causes of the decrease of cacao production are the outbreak of diseases, loss of resistance by aging cacao trees and the insufficient agricultural infrastructure.

However, the production of cacao was on the increase since 1985 in accordance with the extension of a new variety and renewal

of cacao trees.

3) Rice

Total rice production in the Study Area is about 30,000 tons, equivalent to 13.0% of the national production. Rice in the Study Area is mainly produced by small- and medium-scale farmers, but there are several large-scale farmers with planted areas of over 100 ha.

According to the farm management survey, small-scale farmers in the Study Area have a yield of 2.8 to 3.5 tons/ha, and large-scale farmers in Zones A and B have records of 4.9 to 5.1 tons/ha. The average yield of the Atlantic Region is 3.5 tons/ha, exceeding the national average of 3.3 tons/ha. The fact that even small-scale farmers obtain relatively high yields proves that rice is an appropriate crop for the cultivation conditions in the Study Area. Nevertheless, it is a difference of nearly 50.0% between the yield of small-scale rice farmers and that of large-scale farmers. The cause of the difference in yields depends on the inputs of materials for agricultural production and implementation of the flood protection and countermeasure of the poor drainage.

The national rice production is about 230,000 tons (unhusked rice), of which about 11,000 tons is used as seed and about 125,000 tons as milled rice.

According to calculations by CNP about 112,000 ton of rice is consumed nationally per year, and there is an overproduction of about 13,000 tons. The overproduced rice is either exported or food processed. The domestic production price is 30.0 to 40.0 % higher than the international market price. Improvement of export competition can be possible in accordance with the extension of the agricultural supporting services and improvement of the agricultural infrastructure to accompany with the high productivity.

4) Others

Other than the crops already mentioned, coconuts and plantain are also produced in the Study Area. The coconuts planted area is about 370 ha, and the product is mainly for export (JAPDEVA, 1985). Most coconut trees are planted along the Navigable Canal in a scattered form. According to the farm management survey, the average yield is from 2.0 to 3.0 tons/ha. In contrast to other perennial crops, plantain is planted mainly for domestic consumption and average yield is from 5.0 to 7.0 tons/ha.

Annual crops such as maize and kidney beans are cultivated in small amounts in the Study Area, and are produced for self-subsistence of farmers. The average yields of maize and kidney beans are 0.8 to 1.2 tons/ha and 0.4 to 0.5 tons/ha respectively, these figures less than for the surrounding areas, such as Guapiles and Guacimo, as well as the national average 1.7 tons/ha and 1.0 ton/ha respectively.

(4) Production cost and producer's price

The production costs of the major agricultural products in the Study Area are estimated as shown in Annex E Table E 2.2.

For rice production, agricultural machinery costs are about 21% and cost of materials for agricultural production such as seed and fertilizer are about 30% of the total production costs. For other annual crops, labor costs occupy more than 50% of the total production cost. On the other hand, production costs of perennial crops are increasing yearly, however, production costs are to be fixed until to reach the limit yield. The present producer's prices are shown in Table 3.4.8. Maize and kidney beans prices are guaranteed by CNP. The producer's price for rice is not guaranteed as of 1987. Instead of the price guarantee of CNP, the Rice Association (Oficina de Arroz) is offering the new producer's price.

(5) Total Agricultural Production Value

Total agricultural production value in the Study Area is estimated to be approximately 3,230 million colones (US$ 53 million thousand).

A large part of the agricultural production value in the Study Area depends on the bananas production, approximately 78% of the total agricultural production value. The total value of agricultural production in the Study Area depends chiefly on banana production. Zone-D is the most important, accounting for about 38% of the total value. Zone-A shows the least value, at about 13% of the total.

Production value of each crop per ha is shown in Table 3.4.8.

3.4.4 Livestock

The livestock in the Study Area is mainly of beef cattle. In accordance with the statistics prepared by MAG, the number of cattle in the Cantons of Siquirres and Matina is 19,000 heads, which is equivalent to 13% of that of the Atlantic Region. The number of cattle in the Study Area is calculated by the figures of the total number of cattle in the above two cantons compared with each zone.

Approximate number of the cattle in the Study Area are 2,000 heads as shown in Table 3.4.10 .

Table 3.4.10 Number of Cattle in the Study Area (Heads)

| Zone | Number of Cattle | Number of Cattle to Sell |
|---|---|---|
| A | 1,258 | 315 |
| B | 2,264 | 566 |
| C | 1,602 | 401 |
| D | 2,663 | 666 |
| Total | 7,787 | 1,948 |

The total number of cattle in the country is approximately 560,000 heads, and the ratio for cattle production between export and domestic supply is 6 : 4. Annex E Table E.2.3 shows the change of the cattle production over the last 7 years.

Most cattle in the Study Area are Cebu-kind. The cattle graze in natural grassland and are not fed with maize or sorghum. The only feed used is left over plantain and bananas. According to the farm management survey, the average number of cattle per livestock farmer is 3 to 5 heads. Usually, cattle are sold after 3 to 4 years of breeding.

Since the cattle are left in natural pasture to graze, the productivity of cattle breeding is low and the average adult head of beef weighs about 200 to 250 kg. On the other hand, average cattle productivity of large-scale cattle ranchers is about 300 to 350 kg per head, produced from the combination of artificial and natural pasture land; this exceeds the small-scale breeders figures mentioned aboved.

### 3.4.5 Others

In Costa Rica about 1.33 million ha is covered with forest land, which is equivalent to about 26% of the territory. 37.5% of the total forest land is concentrated in the Atlantic Region, including the Study Area, which is the highest proportion of forest land in the country. (Cobertura Boscosa, D.G.F. 1983)

Forest land of about 50.5% (25.5 thousand ha) in the Atlantic Coastal Region is approved as a deforestation area and the remainder is conservation area. About 3,400 ha of the secondary forest exists in the Study Area. The deforestation of the secondary forest is under a license system by the National Forestry Service and it is easy to get a license if a farming plan is submitted.

At present, the bamboo used for the supporting poles for bananas is cultivated in the banana plantation, but an afforestation or silviculture project does not exist in the Study Area.

The Study Area is situated in a favored fishery area but its activities do not include fresh water fish. The experimental cultivation of shrimps, alligators, turtles and tilapia by ASBANA and JAPDEVA have been carried out in recent year, but not put to practical use.

### 3.4.6 Agricultural Supporting Services

Agricultural supporting services for the farmers are conducted by MAG, IDA, MIDEPLAN, SENARA, JAPDEVA, SEPSA, CNP, SBN, and Munincipals concerned.

The activities of the main agricultural supporting services are as follows:

(1) Research Institutions

Leading research institutions perennial crops in the Study Area are the Banana Experimental Station of ASBANA and the La Lola Cacao Experimental Station which is under the responsibility of CATIE.

Another important institution is Agricultural Research of University of Costa Rica in Pococi, outside the Study Area; it conducts cultivation research and prevention of diseases to the perennial crops for export.

The Agricultural Experimental Station, operated in cooperation with the Republic of China, located near the Study Area, is carrying out cultivation research for the annual crops. (see Annex H.2.)

(2) Agricultural Extension Services

Agricultural extension services for the farmers are conducted by the MAG and IDA.

The MAG extension services for fields crops, livestock, fisheries, forestry, fruit and vegetables are carried out by the MAG's Regional Office. The director heads the MAG's Regional Office in Siquirres assisted by the five managers in each technical field. The Regional Office has six branches for extension services, each supervised by an agronomist in charge of six branch offices, and two to four extension workers.

The MAG's extension service covers about 4,000 farmers in the Study Area. Each extension worker is assigned to an area covering about 1,000 farmers; this service cannot be sufficient because of the shortage of extension workers and materials for the extension services.

Extension work on settlement is one of the functions of IDA. Field operations are spread over 19 areas of 18,800 ha, e.g., 29% of the Study Area. In Maryland, there are four agronomists for 259 farmers. The IDA's extension services are at a disadvantage owing to lack of vehicle as well as the poor road network.

### 3.4.7 Farmer's Organization

There are 42 farmers' organizations or societies/groups in the Study Area, such as 9 cooperatives and 33 development associations.
(See Annex H.3)

#### (1) Cooperatives

The cooperatives are made of two saving and credit cooperatives, six agriculture cooperatives, three consumer's cooperatives, three industrial cooperatives and three multiple cooperatives.

a) Saving and Credit Cooperatives (Cooperativa de Ahorro y Credito) - (two groups)

Their main activities are savings, credit and education for the member-families. Savings should be over 100 colon per month per member. These cooperatives provide financial aid to the members to repair houses or purchase furniture.

Due to poor financial resources, crediting depends on saving by the members to fulfill the members' demands. Problems of these cooperatives are (1) no offices for manager, (2) little or no technical management advices from the INFOCOOP, (3) poor

financial resources.

The names of the cooperatives in the Study Area are as follows:

| | | | |
|---|---|---|---|
| 1) | Coope Buena Esperanza | 105 members | Canton of Matina |
| 2) | Coope Carimp | 149 members | Canton of Siquirres |

b) Agriculture Cooperatives (six groups) and Agro-industries (Processing) Cooperatives (Cooperativas de Agricolas y Industriales) (three groups)

Total membership is 284. Out of the six types of cooperatives, only two are running at a profit. These two cooperatives produce bananas to manage banana plantations, processing facilities for grading, washing and packing. Technical assistance is given to the members by the client exporter and management assistance is given by the ASBANA or INFOCOOP officials of the cooperative.

These two cooperatives plan to expand their acreages and processing facilities so that the members will receive additional benefits.

In 1984, Coope-Bataan, one of the banana cooperatives, intended to export to the United States market directly at reasonable prices, but they failed on account of the sales network. Marketing channels are dependent upon foreign enterprises and medium scale banana farms and cooperatives are contract cultivation with them.

The organization charts of the Agriculture Cooperatives are shown in Annex H Fig. 3.

c) Consumers' Cooperatives (Cooperativas de Consumo) - (three groups)

The management is the same as that of the ordinary supermarket. Sales benefit of this type of cooperative is distributed by the cooperative members. The names of the cooperatives in the Study Area are as follows:

| | | | |
|---|---|---|---|
| 1) | Coope Sara | 105 members | Canton of Matina |
| 2) | Coope Bataan | 37 " | " |
| 3) | Coope Veintiocho | 143 " | " |

(2) Development Association

Development association organizations for the inhabitants and are set up in each district with the aim of improving the living environment and developing the Area.

At present, consciousness of the development association is low in the Study Area. Membership is about 30% of the total families, and there are 17 associations in the Canton of Siquirres, and 16 in the Canton of Matina.

Associations hold general meetings, discuss their problems and submit petitions to the Government. Most of the association have new development plans such as drainage improvement and establishment of small-scale rural industries.

The regional office of the DINADECO(Direccion General de Desarrollo de la Comunidad) is located in Limon and Guapiles near the Study Area. Each regional office has a technical advisor for the association's activities in the District of Siquirres and Matina. The provincial level has a federation organization known as "Union Centro de Asociacion de Desarollo", and has an organization to investigate and solve the problems of their activities as well as regional development plan.

3.4.8 Processing and Post-harvest Facilities

Limon is the main producer of bananas, cacao and rice for the

country. Due to the lack of cacao supply, the cacao processing facilities are not being operated at present.

As rice farmers have not suitable unhusked rice storage facilities, it is difficult to keep proper quality till the delivery to forwarder and rice-miller in Battan (storehouse : 6,000 ton + milling capacity : 36.0 quintal/hour).

The quality of the rice is inferior because of poor management control at both cultivation and post-harvest stages for small farmers in the Study Area. About 5.0% of yellow rice is found after polished white rice and broken rice is also high rate of 4.0%.

Maize, taro (tiquisque) and other field crops are grown mostly in homesteads or small plots at the outskirts of dwellings. Buyers of the above crops are limited in comparison with the producers, and the domestic market balance is not favorable to the farmers. Therefore, unless raise the value added or storage by treatment and processing, producer's price is a disadvantage to the farmers. In the Study Area, there are few processing factories and facilities in the main towns as Siquirres, Bataan and Limon. While the regional processing facilities seem necessary, the following tentative observations can be made:

- Most of the cacao crop farmers do not have access to fermentation facilities, drying facilities or processing technology.

- The majority of farmers have no transport for their products or agricultural machinery.

- Most of the tuber crop farmer sells in a low price to buyers or exporters due to no existing processing facilities as washing, drying and packing facilities for export.