CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

1.1.1 Macroeconomic Policy in Costa Rica

(1) Macro economy and Food Self Sufficiency

Agriculture in the Costa Rica has traditionally developed based on the export of tropical products such as banana and coffee. In addition to banana and coffee, the agricultural sector is mainly products fruits and cattle. As the form of agriculture is strongly biased towards exporting production, for supply of the food crops (such as rice, maize, beans and vegetables), the Costa Rica depends on the importing of food crops. The high rate of import of food crops has been becoming as a consequence of the economic policy of the latter half of the 1980s, promoting export orientated manufacturing industry.

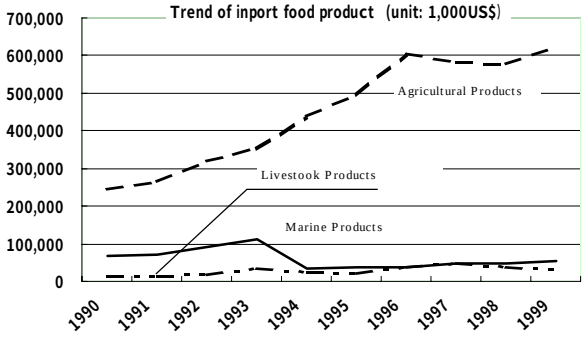
GDP structure in Costa Rica

(unit;%)

Year	1995	1996	1997	1998	1999
Agriculture, Forestry, Fishery	18.7	18.7	18.0	17.9	17.1
Industry, Mining	22.0	21.2	21.5	22.3	25.6
Electricity, Water supply	3.2	3.3	3.4	3.5	3.4
Construction	3.5	3.4	3.5	3.6	3.9
Commerce	17.3	17.0	17.1	16.8	15.6
Transportation, Communicatior	10.3	10.8	11.1	11.2	11.0
Finance, Insurance	7.4	7.7	7.8	7.8	7.5
Immovable	5.8	5.9	5.8	5.5	5.2
Official	7.5	7.6	7.4	7.0	6.6
Others	4.2	4.3	4.4	4.3	4.1
Total	100.0	100.0	100.0	100.0	100.0
GDP Total (million Col)	15,343	15,247	15,852	16,891	18,294

Source : SEPSA, con en informacion del BCCR

The growth rate of the manufacturing industry sector of the last decade (5%, during 1990 – 1999) was higher than that of the agricultural sector (3%, at the same period). The manufacturing sector occupies more than 20% of GDP share, which is larger than that of the agricultural sector (17%). The success of export oriented economic policy has made available the capital required for importation of foodstuffs. The easily accumulated capital has been the underlining factor of largely relying on food importation. The policy for increasing food self-sufficiency in Costa Rica does not aim for protectionism of agriculture but is an effort to increase agricultural production through strengthening of international competitiveness.



(Source：SEPSA, Estudio Economicos e Informacin)

(2) The Central American Common Market and Integration of Central America

On the other hand, as the principle of the free trade of the WTO has been spread into its member countries, the domestic market has been getting out from government control and is starting to tune in to the international market. The market of Costa Rica has also become to be highly influenced from the market of USA and the Central American Common Market (CACM). All member countries of CACM have nearly 60% of their exportation towards USA. In accordance, the member countries are competitors as much as they are cooperates. The next table shows main trading partners of Costa Rica in 1999, 2000.

Trade share and main trading partners of Costa Rica

Destination	1999	2000	Origin	1999	2000
US	51.4	51.8	US	56.4	53.2
EU	21.3	20	EU	9	10.3
CA*	8.6	10.6	CA*	<3.9	4.9
Puerto Rico	2.6	2.8	Venezuela	3.9	5.3
Mexico	2.1	1.7	Mexico	5.4	6.2

* Central America

Although Costa Rica resistances to overall participation to the Political Regional Integration Plan, the table shows that importance of CACM member countries as trade partners is increasing.

The establishment of a free trading zone within the region is the beginning of the Regional Integration. Theoretically, this will be followed by customs union, economic union and finally formed to a common market, which is based on the free movement of capital and labor power in the region.

The three northern countries (Guatemala, Honduras and El Salvador) and Nicaragua are positive for this integration. Only Costa Rica is not positive and there are two factors in the conflict between Costa Rica and the northern countries. One is the tariff rate; Costa Rica is claiming to keep the right for the decision of tariff rate by each country as the key point for self-decision of trading policy, while the other countries claiming the tariff rate to be uniform within the common market. The other factor is the liberalization for the movement of capital and labor power and Costa Rica objects the liberalization based on the regional economic differentials. Incidentally, agricultural labor wages in Costa Rica and Panama highly exceeds those of the other countries. Recently, Costa Rica is trying to make agreements on a Non-Symmetrical Free Trade Concord with outside countries from the region. The concord was agreed with Mexico five years ago, the concord with Chile was accepted by the congress in December 2000, and the concord with Canada was signed by on April 2001.

(3) Comparison of Market Sizes of Sugar, Rice and Other Major Crops

The traditional exports of Costa Rica are bananas and coffee, while ornamental foliage plants and flowers are being newly exported. In fiscal year 1999, the amounts of export were; 630 million dollars for bananas, 310 million dollars for coffee, 210million dollars for fruits and 120 million dollars for ornamental foliage plants/flowers. The export of sugar, on the other hand, was 30 million dollars, and falls below beans/vegetables which was 53 million dollars only.

Costa Rica imports four kinds of major crops. In fiscal year 1999, the amounts of import were; 35 million dollars for wheat, 48 million dollars for maize, 32million dollars for frijoles, and the trade balance of rice was 13 million dollars.

The above-mentioned amounts showing that the trade amount of rice and sugar were relatively low. On the other hand, the government of Costa Rica invested in the construction of irrigation facilities of the Arenal Multi-Purpose Dam plan for production of rice and sugarcane.

The government controls the domestic market to maintain the advantage of sugar trade in the international market. On the other hand, the government is starting to loose power upon the control of the rice market.

1) The Sugar Market

The market is controlled by Agro-industrial Union of Sugar Cane (LAICA). The planned production of sugar for the harvest stage of fiscal year 2001-2002 is 320 thousand tons, consisting of 72% for export and 28% for domestic consumption. 17% of the export is for the trade the USA.

2) The rice market

For the quantity of rice/unhulled rice supply, the yield of unhulled rice is estimated as 2.82 million tons in fiscal year 1999-2000 based on 680 thousand ha of planted area and 4.17 t/ha of unit yield, so

the amount of rice production is estimated as equivalent to 1.88 tons of rice. On the other hand, for the demand of rice, from the estimated annual consumption for one person (54 kg/person) and national population (around 4 million), the demand of rice is estimated as 2.16 million tons. Therefore the shortage of 28 thousand tons (13% of the demand) is estimated as the necessary amount of importation.

According to the Bureau of Rice of the Ministry of Agriculture and Livestock, the shortage of rice for fiscal year 2000-2001 was assumed to be 38 thousand tons. However, as 53 thousand tons of rice was imported by the traders, 15 thousand tons of surplus rice came to domestic market and the market became unstable. Usually the rice stock of rice millers is rotating with 2 months, but rotation time was expanded 3 to 5 months in this time. Consequently, the millers refused to buy unhulled rice from the farmers in many case. The imported rice is mainly produced in Louisiana, imported as unhulled rice and debarked at the port of Caldera on the Pacific coast.

(4) Expectation of Tourism

As there are a lot of beaches with nice view, stirring volcanic areas, natural conservation areas with valuable species of animals and plants in and around the Peninsula of Nicoya including Guanacaste province, this area is expected its regional development as the one of the prominent tourism zone. The tourist hotels with totally around 5,000 rooms in Guanacaste have been constructed and those rooms are nearly full occupied in the Christmas season with so many tourists. Considering the approximately 400 thousands of foreign tourists coming every year and December to April of the tourism season, the new agricultural market for the food demand in this period can be expected if timing of crop planting can be adjusted. However, it is necessary to consider those the demand is not stable through out the year, the payment from the Hotels is usually delayed more than one month, the high quality of product is required for the tourists, and so on.

1.1.2 The Arenal Tempisque Irrigation Project (Phase I、Phase II)

In Guanacaste province, which is one of the main production areas of food crop, the Arenal Tempisque Irrigation Project (proposed irrigation area 59,960 ha) was planed in 1978 before the economic crisis. Phase I Project was completed in 1985, and 6,000 ha of agricultural land become to be irrigated with the water from the head works newly constructed. The completion of the Project has contributed to the increase in rice production (the rice production was increased to 260,000 tons from 140,000 tons in 1960s) and the self-sufficiency rate of rice also improved from 50% to 68% (SEPSA, 1990). Also the production of maize and frijoles were increased, and the import of food crop was reduced. However, due to the increase of food demand caused by population growth and due to abnormal weather from the later half of 1980s, food import has considerably increased and the condition relying on importation for 30% of food supply has been continuing.

On the other hand, in the Phase II Project, the supply of irrigation water was started in 1995 for some parts of project area, and with the completion of the construction in 1999, 12,000 ha of irrigation area was newly improved. Therefore, 18,000 ha of irrigation area (beneficiaries: 850 farmers) is improved by the Project. 50% of 18,000 ha of irrigation area is belonging to the small farmers who were settlers immigrated by the settlement project of the Institute of Agrarian Development (IDA).

1.1.3 Phase III Arenal Tempisque Irrigation Project

In the “policy of agricultural and live stock development and rural environment improvement (Politicas para el Desarrollo Agropecuario y del Medio Rural Costarricense)” which was proposed by the new government in 1998, the main focus of agricultural policy are placed on the strengthening of competitive power in exporting agricultural production and improvement of rural environment as well as the promoting of agricultural production of exporting crops. After joining WTO, free import of agricultural production has been promoted in Costa Rica, and the production of rice, maize, wheat and frijoles has decreased remarkably. The Arenal Tempisque Irrigation Project started the procedure for the implementation of Phase III Project in 1995, and SENARA succeeded to get the finance from

private sector for the Phase II construction of the west main canal. With the compression of the Phase III project, around 10,000 ha (beneficiaries: 125 farmers) of irrigation land will be improved. The construction was started at the end of 2000, and will be completed at the middle of 2003.

1.1.4 Phase IV Arenal Tempisque Irrigation Project

At the moment of the implementation of the Phase III Project, the current study was proposed for the area of the middle basin of the Tempisque river and the proposed project in this study can be considered as the Phase IV Project.

In the Arenal Tempisque Irrigation Project, the irrigation water for 59,960 ha of agricultural land was expected to be obtain from the Arenal-Corobici Hydro-electric Power Station (ARCOSAN) at first, however, it became clear that there is no sufficient water for the total area of the Project and the irrigation water supply for the right bank of the Tempisque river become to be difficult. Furthermore, as the regional and international conditions surrounding economic and agricultural situations have been changing, this study is requested to formulate the sustainable integrated agricultural development plan including the improvement of food self sufficiency through the increasing of the food crop production which is oriented by Costa Rican Government, the strengthen of international competitive power for liberalization of trade, the correction of regional difference from other area, and environmental conservation.

Therefore, this study expects toward the integrated agricultural development including flood protection, environmental conservation, strengthen of agricultural supporting as well as irrigation and drainage improvement.

1.1.5 Phase V Arenal Tempisque Irrigation Project

The surplus water of the discharge water from the ARCOSAN hydro-electric power station was planned to use for Lajas and Abangares areas where the river water is drying up in the dry season and there is no other water resources for irrigation. In the Phase V Project, the Phase II expanding construction works of the south main canal (between the Cañas and the Abangares rivers), the construction of irrigation canal networks in both areas and the improvement 7,000 ha of the irrigation land are planned.

Therefore, the total irrigation area using the water from the ARCOSAN hydroelectric power station will be approximately 35,000 ha.

SENARA is now carrying out the detailed design of the facilities for Phase V Project, the procedure of obtaining the finance for implementation will be started after the completion of the detailed design.

1.2 OBJECTIVES OF THE STUDY

The Objectives of the Study are as shown below;

(1) Based on the request of the government of Costa Rica, for the 35,000 ha of the area at the middle basin of the Tempisque river in the Guanacaste Province, considering the environmental conservation of the national park in the upper and lower areas, for the purpose of the establishment of irrigation and drainage agriculture, establishment of countermeasure for rural flood protections and promoting the sustainable agricultural development of the small and medium scale farmers, to reevaluate the existing development plan (Arenal Tempisque Irrigation Project) and formulate the preliminary development plan, To conduct a feasibility study on the proposed project in the preliminary plan.

(2) For the Costa Rican counterpart personnel, to carry out the technology transfer on the methodology of the study and the procedure and thinking way for the formulation of the development plan.

1.3 STUDY AREA

The plan shall be formulated the area that covers approximately 35,000 ha along the Middle Basin of Tempisque River including Liberia, Santa Cruz and Carrillo cantons in the Guanacaste province. Furthermore, studies on hydrology, environment, and agro-economy shall include the surrounding areas of the target area.

1.4 SCOPE OF THE STUDY

The Study consisted of Phase I study (evaluation of existing plan and establishment of preliminary development plan) and Phase II study (execution of feasibility study) and was carried out from 2000 to 2002. This report was prepared as F/S report describing the current situation of the Study Area and the proposed development plan based on the entire study results, including field survey results and successive analysis conducted in Japan.

CHAPTER 2

BACKGROUND

CHAPTER 2: BACKGROUND

2.1 GENERAL CONDITIONS OF COSTA RICA

2.1.1 General

Costa Rica is located at latitude 10°00' North and longitude 84°15' West and lays adjacent to Nicaragua on the Northeast, Panama on the Southeast, Pacific Ocean on the West, and the Caribbean Sea on the East. The territorial area of Costa Rica is 51,100 km^2 consisting of 7 Provinces, 81 Cantons and 463 Districts administratively. According to the national census performed in 2000, the population of Costa Rica is around 3.5 millions, with the population density of 67.4 person/km^2 distributing 44 % for the urban area and 56 % for the rural area. An average number of families is 4 persons /household, literacy rate is 95 %, rate of public school is 88 % and there are 4 public Universities. The life expectancy is 79.8 years for women and 74.1 years for men. Infant mortality rate is 11.8 per 1,000 life births in 1999 and this rate is the minimum level for historical rates of the country as same as that in 1996. The unemployment rate is 6.0%, the highest rates of sub employment were seen in Chorotega (17.9%), Brunca (16.8%) and Huetar Atlántica (16.4%) regions. In 1999 the economic active population (PEA) was about 1,383,000, including potential population. Especially, The number of women labor forth has been continuously increasing, and the share for the total PEA was 33.1% (458,000 persons) in 1999.

The main traditional exporting products are banana, coffee, meat and sugar and, recently, new products such as electronic parts, pineapple, medicines, decorations plants, synthetic rubber for packing, women garments, fish, tires, glass containers and polyester fiber are exported. In 1999, the GDP was increased largely with 8 % of growth rate and the growth rate of GDP per capital marked 5.5%, which is the highest rate in the countries of Central America. This economic growth contributed to restraining of inflation and Economic stabilization. In 1999, the economy continued to be stable under the influence of the inflation control (10.1%). The average monthly income of workers increased from 53,245 colons in 1998 to 54,183 colons in 1999. On the other hand, the poverty rate kept a level of 20.6% of all households, and the rate of extreme poverty increased to 6.7% (1999).

In 1999, Costa Rica counted the first trade surplus in the past several ten years. Although the increase rate of nominal exportation was less than that of 1998 (18.1% in 1999 and 27.4% in 1998), the low increase on importation (0.5%) resulted in a trade surplus equivalent to 1.5% of the GDP. Nevertheless, excepting electronic parts, the export is gradually decreasing. This shows the facts of productive structures with high dependency on the importations, and of low adding value of the main exportations.

2.1.2 Agricultural and Livestock Sector

The productive structure of Costa Rica has radically changed since 1960, especially in industrial and agricultural (including live stock) sectors. In those years, the productive shares were; agricultural sector 26%, commercial sector 20%, service sector 19%, industrial sector 14%, and the agricultural sector was the most important sector of national production. In 1970, the industry sector overtook the commerce sector and, in 1980, industrial sector had the highest share of GDP. This tendency has been continued following ’90s and the GDP share of industrial sector became to be 26 % in 1999. In contrast, the agricultural sector fell down from 25% in 1960 to 18% in 1980 and, the GDP share of agricultural sector has reduced to 11% in 1999. But, the production of agricultural sector has not decreased; it was increased 38% comparing with 1991 (1991 price). In spite of decreasing of GDP share, the agricultural sector still is one of the major sectors for creating the job opportunities for employer (19.73% of total labor force). The agricultural sector consists of three sub-sectors: agriculture, livestock and others (forestry, fishing, agricultural improvement). The main products are coffee, bananas and the non-traditional products (especially flowers, melons, marine products and pineapple). The productions of non-traditional products were increasing for the policy of the promotion exportation and crop diversification especially since the middle of the ’80s. Nevertheless in the recent years, the agricultural and livestock productions has decreased as 0.4% in 1996, and 0.7% in 1997; in contrast with 6.2% in 1991 and 4.1% in 1992.

The main problems are shown below.

- Continuation of protection principle for some products (chicken meat, milk and dairy products, rice and sugar cane).
- Non-consolidation of farmers' organization (Community bank, Committee of Rural Credits, Basic Agriculturist Centers).
- Insufficient information of products with high marketability and exporting potential (development of fish raising industry for export).
- Problems in execution of crop diversification.

2.2 GENERAL CONDITIONS OF CHOROTEGA REGION

Chorotega region is almost same area as the area of Guanacaste province, located in the northeast of the country and its feature is a vast area with low population density. In spite of covering 20% of the Costa Rican territory, the population in this area is about 8% of the total population in 1999.

Before 1950, the social and productive development in the low flat land of Guanacaste was proceeded based on economic activities represented by the traditional big cattle farms. The production was shipped to domestic and Central American markets. After 1950, the economy of Guanacaste had met drastic turning point and the new production system was established instead of old ones. Furthermore, the big cattle farms were revitalized with opening of cattle meat and sugar cane market of USA, on the other hand, the productions of rice, cotton and sorghum for domestic market were also revitalized. In those years, the government of Costa Rica tried to intensify the development of Guanacaste, and the public works such as rod network (trunk road, domestic road) constructions were carried continuously. As a result, the accessibility connecting capital city or other regions was improved. Furthermore, the form of regional land tenure was changed with the construction of the Arenal Dam and improvement of the irrigation land in the region. The government also installed more primary and junior-high schools, hospitals and clinics in the Guanacaste Province, promoted production of industrial products such as sugar, alcohol, cotton and cement during the second half of '70s to the first half of the '80s.

However, the agro-industrial sector of Guanacaste was discouraged at 1980 and the regional economy in the Guanacaste faced the tuning point again in 1990s. The agricultural and livestock sector as the most major industrial sector by that time was changed place by service sector (truism) gradually and this tendency is still continued now. In 1999, the number of foreign tourists visiting to Chorotega region was 384 thousands. The average annual increase rate of tourists visiting for last 5 years was 4.8 % and tourists stayed for 3 days averagely. The occupancy rate is 50 % for lodging facilities called "tourist hotels" and it is 40 % for the other accommodations. Also, there are around 181 thousand local tourists but most of them stay in accommodations besides the tourist hotels.

On the other hand, the agricultural and livestock sector was discouraged and it continues to decline now. The activities of modernization for agriculture concentrated on a few parts of productive activities (for sugar cane, rice and melon) the crop diversification is delayed. The Chorotega region is one of the major rice production area in Costa Rica and there is 45.3 % of rice planted area in 1989-1999. 45.8 % of the national sugar production and more than 50% of the total sugar cane are produced and processed in the Guanacaste. Although small and medium-scale farmers both participate in production activities of rice and sugar cane, the main production are in the hands of big enterprises. Nevertheless, the rate of sugar production by private farmers has increased recently (from 31.7% in 1991 to 45.6% in 1998). Guanacaste is the most important melon production area of the country, sharing 71% of the national production. As for milk cows, more than 20% of total number of milk cows is breeding in the Guanacaste.

There are many protection areas for natural environment, reforestation is done very well, government and local people are promoting positively the conservation of natural resources in region; those are also ones of the feature of the Guanacaste Province. However, the water resources are scarce and average annual rainfall is around 1,700 mm comparatively lower than 3,300 mm of average annual rainfall for all country. The main water sources ordered bi its importance; Tempisque River Basin (a

habitant of various animals and plants), the aquifer at the right bank of the Tempisque river and Arenal Lake (a key water source for the production activities of Cañas and Bagaces). On the other hand, the inundation has occurred frequently in September and October 1999 and the frailty of social infrastructure in the Guanacaste has been exposed. The various social problems in the region were caused by frailty of urban planning and land planning. The local people is harmed by inundation every year and the damages of inundation has been expanded in conditions, such as, occurring frequency of inundation becomes to be high, the population in the right and left bank area of Tempisque river is increasing, deforestation in the entire basin is expanded.

As for energy production, the Chorotega is one of regions with high importance in the country. In the Guanacaste Province, there are hydraulic (Arenal-Corobicí-Sandillal Complex), geothermic (Miravalles Volcano) and wind (Tilarán) power stations and they are producing 27% of the nations electricity. The small-scale plants using biomass and solar energy also exist.

The largest poverty population (35.5 % of total employments) exists in the Chorotega region from a consideration based on the poverty standard in Costa Rica and many of people has been out flowing to other regions from old time. The income level is the lowest in the all country and the low in come employment index is the highest (17.9 % in 1999). This is caused by the big seasonal fluctuation of main economic activities (production of sugar cane/melon and tourism). Recently, The female worker population is increased rapidly in the Chorotega region and the potion of female worker was increased in the Guanacaste from 21.6% in 1987 to 30.2% in 1999.

As for medical treatment, the jointing portion to EBAIS achieved to 100% and infant mortality is keeping the same level as average of national level. The rate of moderate or strong underfeeding is lower than that of the average of national level. As for educational condition, the educational and enrollment rates are the second highest in the country after the Central region.

2.3 ARENAL TEMPISQUE IRRIGATION PROJECT (PRAT)

2.3.1 Antecedence

SENARA, after its' establishment, took over the Itiquis Irrigation District (before, the project of MAG) and DISTRA (before the project of SNE); both were big scale irrigation (macro riego) improvement projects. After those projects, SENARA had improved the Osa, Golfito y Corredores irrigation, drainage and soil conservation area and also has been carrying out the irrigation and drainage improvement projects for all the country based on the National Small Scale Irrigation and Drainage Plan (PARD).

Arenal Tempisque Irrigation Project (PRAT) is a project to improve the two big irrigation areas (Arenal: 40,060 ha, Zapandí: 19,900 ha) for the purpose of irrigation agricultural development of around 59,960 ha of irrigation land with the water source from discharge water of Arenal-Corobicí-Sandillal Hydroelectric Power Station (ARCOSAN). The Project has been implemented with several Phase with the priority sections of: maintenance of infrastructure, extension services, irrigation research & demonstration, social development of beneficiaries, reinforcement of SENARA functions and environmental conservation.

2.3.2 PRAT Phase I - Phase II

(1) Project Summary

The plan of using the abundant surface water from the Arenal river basin (average annual rainfall: 3,820 mm) and the Cote river sub-basin (4,710 mm) both located at the Atlantic Coast for the Tempisque River Basin located at the Pacific Coast where has scarce water resources (average annual rainfall: 1,545 mm), is to realize integrate use of water resources for ARCOSAN and PRAT. Arenal lake is the big scale perennial reservoir controlled by ICE, the plural hydroelectric power stations can be can generate electricity during the dry season with this water source. From the reason of effective use of water for both; power generation and irrigation, the PRAT was planed for irrigation using the l water from Arenal lake.

The hydroelectric power stations of Arenal and Corobici have three turbines with the capacity of 157.4 MW and 174 MW respectively. The discharge water is restored to Sandillal reservoir for adjustment the water volume weekly. After that, the water is used for turbines generator (32 MW) at the machine house of Sandillal, consequently, the water is discharged into the Magdalena River. The reservoir and power station of Sandillal are also use for adjustment of irrigation water. The Magdalena Dam stores the river water and this discharge water, but, as storage volume is no so large, the Dam discharge the surplus water to wet and south main irrigation canals.

The PRAT is a plan of irrigation development for approximately 60,000 ha. The plan is implemented dividing the area into two districts; The Arenal district with approximately 40,000 ha (south: Cañas, Lajas and Abangares irrigation blocks, west: Piedras, Cabuyo and Tempisque irrigation blocks), and the Zapandi district with approximately 20,000 ha (South Zapandi and North Zapandi irrigation blocks).

The DRAT was implemented in two stages as follows:

Phase I. Beneficiaries: 168 farmers (including pilot project area and existing farm lands in Cañas), irrigation land 6,371 ha (Cañas: 5,360 ha, Cabuyo: 700 ha, and Lajas: 311 ha). Using the South Main Canal (length: 8.5 km, discharge: 30 m^3/s). investment: 19.8 million dollars.

Phase II. Beneficiaries: 632 farmers (including pilot project area and existing farm lands in Cañas), irrigation land 7,070 ha (Piedras), 4,541 ha (Cabuyo including 983 ha in Bagatzi), Using the West Main Canal (length: 21.7 km, discharge: 55 m^3/s). investment: 38.46 million dollars. In the summer of 1999, an additional 1,400ha of land was improved in Lajas by private investment

Phase	Account (Million U.S. $)	Irritation canal (km)	Drainage canal (km)	Road (km)	Area (ha)	Beneficiaries (farmers)
1	19.80	79.31	23.13	68.46	6,371	168
2	38.46	154.92	66.32	162.37	13,011	632
TOTAL	58.26	234.23	89.45	230.83	19,382	800

Source: SENARA

The total area covered by PRAT reached 19,382 ha, and the number of beneficiaries is approximately 800 farmers.

(2) Agricultural Socioeconomic Impact

The purposes of PRAT were set as; to increasing of basic grain production at mainly the Arenal irrigation block, to acquire the foreign currency, to improve the socio-economic conditions in the region, to promote the employment, to increase the income of producers, to promote the agriculture and livestock development. The Arenal Tempisque Irrigation District Project (DRAT) has largely contributed to those objectives. For specific objectives, the followings were set.

i. To contribute the improvement of self-sufficiency through converting from non-irrigated extensive agriculture to irrigated intensive agriculture and increasing the basic crop production

The area of rice fields in the project area was increased since the 1995-1996 and, in the 1996-1997, DRAT shared 47% of the irrigate land of the all country (17,600ha).

For the planted are approx. 44,000 ha in the 1996-1997, planted area in DRAT shared 21%. Rice production is creating employment opportunities, sharing 21 % of calorie intake of Costa Rican nation, sharing 8 % (representing the lowest rate in purchased food of household economy) of the price of the “canasta básica” (the minimum requirement for livelihood). Therefore, rice production may be acknowledged to have great importance. For 1988-1997, the consumption of rice per one person has increased from 43kg/year to 55kg/year by irrigation agriculture in DRAT. After introducing of double rice cropping, the productivity of rice has considerably increased showing a rate of 246%; from 3.0 t/ha/year to 10.4 t/ha/year. The productivity of a single crop has also increased 73 %, it is highly

exceeding the target as 65%.

As for sugar cane, Guanacaste refines approximately 1,430,000 t/year of sugar cane, which is 50 % of the national production, and produces approximately 147,000 tons of fine sugar, which is 45.8 % of national production. In DRAT, the Toboga sugar mill refines approximately 544,000 tons of sugarcane, which is 17.25% of total national production and 30 % of production of Guanacaste, and the production of fine sugar also holds 18% of the national production. The export of sugar increased from US$25,072,300 in 1990 to US$44,433,900 in 1996. The productivity of sugar cane has also increased by the rate of 43 % from 70 t/ha/year to 100 t/ha/year with the introducing the irrigation.

ii. To improve the socioeconomic conditions and living environment of the regional residents through promoting employment opportunities and increasing income of producer

In 1997, population increased by the rate of 17 % in Cañas and 7 % in Abangares. The rate of enrollment has increased by 10 % in the project area. Three private primary schools were established in the area; where there were none before the project implementation, and three junior high schools (including one night school) were established. Three universities were also established; two in Cañas and one in Bagaces, where there were none before the implementation of the project. Illiteracy decreased from 9.32% to 8%. For residential, before the project, most were wooden houses with bad latrine toilet and water supply from wells. Currently, most houses are made of concrete with an average or 4 rooms, and equipped with drinkable water and septic tanks. For the waste derived from the 5,600 homes of Cañas, 74% is collected through public services, 5% is under grounded, 18% is burned and 2% is throw away to the fields or rivers.

For Community Organizations, there are 11 EBAIS (Basic Teams of attention integrated in health), 4 in Bagaces and 7 in Cañas. The Montenegro community has particular benefits from DRAT. One health control place, one grocery, one canteen, one primary school and concrete houses (mostly newly-built) were equipped as the population increased to 4,300.

Other organizations in the area are as follows:

Falconiana:	Cropping Association and Communal Bank.
La Soga:	Comunal Bank BanSoga S. A. La Soga Cropping Association. La Soga Water User Society. Rice Producers Association United Rice Cropping Cooperative. Rice Trust of DRAT.
Cabuyo	COOPEBAGATZI, Asociación de Productores de Bagatzí

(3) Land Tenure

The number of beneficiaries through PRAT Phase II in Piedras and Cabuyo and their form of land tenure is shown below:

Land Tenure of the Project Area

Land Scale (ha)	No of Farmers	%	Area (ha)	%
Less than 20	737	96.6	5,438	40.9
20 to 100	16	2.1	1,000	7.52
More than 100 *1	10	1.3	6,860	51.59
Total	763	100	13,298	100

*1 Include 423 ha. of Lorraine S.A. which the government plans to expropriate. After expropriation, the land tenure by small farmers and big farmers will be 44,1% and 48,4%, respectively.

The PRAT Phase II has obviously transformed the land tenure in Piedras and Cabuyo areas, increasing the number of farmers with land smaller than 10 ha from 195 to 737 and the area of these lands from 1,972 ha. to 5,438 ha, increasing by a rate of 176%. These areas hold 41% of the irrigation area. When

including the area owned by Larraine S.A., the increase goes up to 198% and the land tenure of the small-scale farmers would be 45%. On the other hand, land owned by bigger farmers with areas over 100 ha decreased with a rate of 25%, from 9,156 ha. to 6,860 ha. This holds 51.5% of the irrigated area. When including the Lorraine S.A., the rate of decrease will be 30%.

(4) Credit

The credit for farmers under the National Bank system has been considerably reinforced. Credit supported from the Bagaces branch of the National Bank Agency was approximately 300 million colons in 1995/1996, and increased to 1,600 million colons in 1999. The main purpose of the financial support is for the equipment of farmland facilities and to fund agricultural activities. The National Bank estimates 778 million colons as the fund necessary for agriculture credits in Phase II, which represents 75% of the credit foundation.

The credit foundation of the Cañas branch office of the National Bank Agency increased by the rate of 116%, from 2,264 million colons to 4,885 million colons from January to December of 1998. At the same period, agriculture credits increased from 560 million colons to 1,401 million colons. The credit foundation is distributed as 18% for rice crop, 42% for sugar cane and 4% for equipping farmlands.

(5) Impact of The PRAT Phase I-2

The expected impacts of Phases 1 and 2 of the PRAT are as listed below. As project is still immature, Some of the impacts are not yet completely actualized.

- ⇒ Establishment of the Mula green belt (the biological runner), between Lomas de Barbudal and Palo Verde and limitation of agrochemicals will improve the environment of Bagatzí by enabling the migration of wild animals from Barbudal to Palo Verde or vice versa.
- ⇒ Suitable conditions for the installation of the Bagaces hydroelectric power station project were prepared.
- ⇒ Entering of private enterprises to the fish farming business was promoted.
- ⇒ Private enterprise got the interest for the expansion of Bagatzí Canal, and the improvement of 8,000 ha of irrigation land at Tempisque area was promoted.
- ⇒ With participation of private enterprises the South Canal was expanded.
- ⇒ The Government purchased the lands at Piedras and Cabuyo and distributed the land small-scale farmers. (there are some report about the lack of living infrastructure: EDN report)

The following impacts of PRAT are also expected from the viewpoint of sustainability, and some of these impacts are in appearance.

a) Promotion of agricultural development through irrigated intensive irrigation. The conversion of extensive cultivation into irrigated agriculture will consolidate agricultural activities and benefit in the socioeconomic situation of the communities. Sustainable development relies on eco-conscious agriculture, which is performed through educating, training and informing to the farmers and common inhabitants. Therefore, the educational activities of public agencies such as INA, ICR and MINAE play an important roll.

b) Increasing of basic crop production and food self-sufficiency rate. Particularly for rice, the increase of paddy fields will largely reduce import.

c) Acquisition of foreign currency through increase of crop production. This will be enabled by providing education, training skill, finance and information, and by strengthening enterprise management.

d) In the lack of information on the world market and under Total Quality Control (TQC) where spreading of production is limited, domestic products are mainly distributed within the domestic market. There are enterprises obtaining foreign currency by exporting fish (Tilapia). This

represents the "moving forward" of the approach towards the objectives, and also means that chance of employment is being formed directly within the agricultural sector.

Moreover some additional things that could be obtained are:

⇒ Decrease of population out flow from the region, especially from Cañas.

⇒ Raising agricultural production and increase farmers' income.

⇒ New employment opportunities in the region.

⇒ Promoting farmers organization, improvement of educational standards through training process for farmers.

⇒ Promote skill development by large and middle scale farmers.

⇒ Improve the land distribution.

⇒ Multiplier effect on the regional economy.

⇒ Ensure sustainability of project objects by adding environmental protection as a component. In addition of the effect on production increase of the project, the living environment of benefit farmers is improved

2.3.3 Future perspectives of the PRAT

At the implementation of Phases 1 and 2 of the PRAT, the Government spent a large quantity of financial resource, one third of the irrigation area was improved. For the development of the following Phases, it is expected to have high impact on regional and national economy with less investment. Though the soil of the Guanacaste Province is suitable for agriculture, rainfall is disproportionate. Droughts and floods cause large damages to crops and obstruct the growing of the region and spur the outflow of the population. Furthermore, damages to the regional economy by the climatic changes due to the El Niño phenomenon and periodical droughts in the Chorotega region are also reasons that hasten the expansion of irrigation areas.

(1) Phase III and Phase V

Phase III is planned to cover the western part of the irrigation area; Cabuyo, Tempisque and South Zapandí, with 15,500 ha, and Phase V is Planned to cover the Lajas and Abangares with 7,500 ha.

Phase	Sub District	Main Canal	Canal Extension (km)	Area (ha)	No. of Beneficiaries*
3	Cabuyo/Tempisque/South Zapandí	CO-II	18	15,500	105
5	Lajas/Abangares	CS-II	32	7,500	250
		TOTAL	50	23,000	355

* Beneficiary includes 100 farmers (approximately 1,000 ha) settled by IDA San Ramon

Phase III is the expansion of west canal, the maintenance plan of section II (Piedras river to Cabuyo river), which is expanding the facility equipped in Phase II to the Cabuyo river. The estimate of investment is approximately 4 million U.S. dollars, and will be done by private enterprises, using the private finance. Initially, 10,000 ha of land will be irrigated. A majority of the land is presently being irrigated using water from Tempisque river by pumping. Phase V has the objective to establish bases of sustainability and integral development of the project through the irrigation of 7,500 ha of land in Lajas and Abangares sub areas, using approximately 22.63 million U.S. dollars. The primary and secondary canals for irrigation along with road systems are planned by utilizing the infrastructure facilities equipped in PRAT Phase I, with the intersection with Cañas river as the starting point.

(2) Phase IV

In the recent survey done by SENARA and ICE, it was concluded that the capacity of irrigation utilizing the discharge of ARCOSAN hydroelectric power station is 35,000 ha and that the capacity must be distributed to the following areas: Cañas, Piedras, Cabuyo, Lajas, Abangares, and a part of

Tempisque and South Zapandi. Thus, the government of Costa Rica requested the implementation of this study; “The Study on Rural Development Project for the Middle Basin of Tempisque River”, targeting 35,000 ha of the middle basin of Tempisque river (Guanacaste) to Japan International Cooperation Agency (JICA) with the objectives of establishing agricultural irrigation system, regional flood control and sustainable development of small and middle-scale farmers, considering environmental conservation of the areas including the upper stream of Tempisque river and the national park of down stream. This study is of revising the existing development plan (Arenal-Tempisque Irrigation Project), drafting a new development plan and conducting it’s F/S. The development plan shall be proposed in this report, by Study team and Counterpart personals of the government of Costa Rica.

CHAPTER 3

THE STUDY AREA

(3) Vegetation

The Study Area is highly deforested. There are great extensions of sugar cane and rice plantations. Endemic species were not found in and around the Study Area. Furthermore, forests are found as scattered patches and on both sides of the river, representing 3.7% of the Study Area. The remaining forest is composed by an 11.7% of Tropical Dry Forest and by an 88.3% of Transitional Forest (Basal Pre-mountainous Humid Forest to Tropical Dry Forest). As for four of the patches, trees such as Guanacaste and Tempisque surrounded by bushes with vines and thorns are seen. For the 27 patches of transitional forests, trees such as Espavel and Cedar prevail. On the river-terrace and the flooded area, occupying 880ha (of which 180ha belongs to the Tempisque River), regional indigenous species such as Uva de Monte and Guacimo spread intersperse.

3.2.2 Hydrometeorology

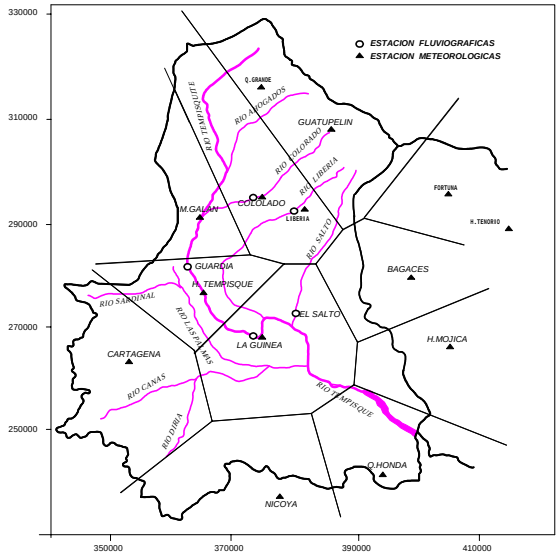
(1) Meteorology

1) General condition

The majority of the Central American countries are divided into two climatic zones, the Pacific and the Caribbean. The weather of the Tempisque basin is influenced by the conditions, which govern the mountain slopes of the Pacific Ocean side of the Volcano Mountains in the upper stream of region. Those are related to conditions such as the movement of tropical depression cyclone, occurring of tropical cyclone, and the deep troughs in the lower and middle troposphere occurring at the eastern region. In the Pacific coast zone, a lot of rainfall is also brought to the mountainside under the influence of the Torrid Zone cyclones of the Caribbean Sea.

2) Meteorological Observation Network and Selection of Available Meteorological Stations

A number of meteorological observation stations are installed in and around the Tempisque basin, but most of them observe only rainfall, and has different features of observed period and data continuation. Considering data availability, 10 rainfall stations for the estimation of the mean rainfall based on Thiessen Polygon shown in the figure, and 2 climate stations for the estimation of the potential evapotranspiration of crops, were selected.



Thiessen Polygon

3) Rainfall

Distribution of the annual rainfall in the Tempisque basin is 1,800 to 2,100mm in the foot of the southern and northern mountains (southern mountain side of Orosi volcano and the northeastern mountain side of the Nicoya peninsula) and 1600mm in the middle basin, it is 200 to 500 mm less than that of the mountainsides. The average maximum continues rainfall at each rainfall station for 1 day, 2 days, and 3 days with the values of exceedance probability (5,10,50 and 100 years retune period) is shown below.

The average maximum continues rainfall (Exceedance probability: mm)

Duration	1 day				2 days				3 days			
Return Period	1/5	1/10	1/50	1/100	1/5	1/10	1/50	1/100	1/5	1/10	1/50	1/100
Mean	123	142	186	206	175	203	269	298	216	251	331	366

CHAPTER 3: THE STUDY AREA

3.1 GENERAL DESCRIPTION OF THE STUDY AREA

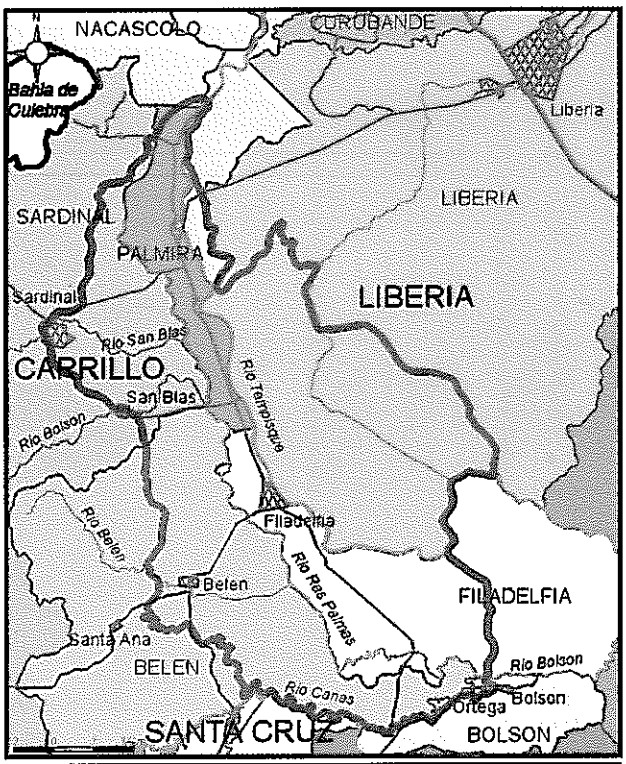
3.1.1 Administration

The Study Area is located in the Guanacaste Province. In Guanacaste, there are eleven (11) cantons and three (3) of them are related with the Study Area. Relation between the districts and the Study Area come as follows:

The capital of Guanacaste Province and Liberia canton is Liberia city, where is outside of the Study Area. Two of the five districts of Liberia canton is relating to the Study Area. Only Liberia district is located completely at the left bank of Tempisque River and some part of the district along the Tempisque River is included into the Study Area. Nacascolo district is located at the upper stream of Liberia district covering both sides of the Tempisque River, though most of the area is at the right bank. A small area of the district, as a slender strip on the left bank of the Tempisque River is included in to the Study Area.

The capital of Carrillo canton is Filadelfia city. There are four districts in the Carrillo canton and each of them is relating to the Study Area. Palmira and Filadelfia are located along the right bank of the Tempisque River and the former is in upper stream. Palmira district is included entirely in the Study Area, while as for Filadelfia, the area excluding the downstream swamps areas with no residence, are included.

Sardinal and Belén are located interior from the river behind Filadelfia and Palmira. For Sardinal, which is the district at the upper part, areas excluding the mountainous and costal areas are included in the Study Area, while for Belén, the area excluding the mountainous areas are included.



Provincia	Canton	District:
Guanacaste	**Liberia**	(2/5) : Nacascolo、Liberia
	Carrillo	(4/4) : Palmira、Sardinal、Belén、Filadelfia
	Santa Cruz	(1/9) : Bolson

Administrative division

For Santa Cruz canton, which is located in the south of Carrillo canton, the capital is Santa Cruz city, located out of the Study Area. As for Santa Cruz canton, a small part of the Bolsón district, projecting at the left bank of Bolsón and Cañas rivers, which are branches of the Tempisque River, is included into the Study Area.

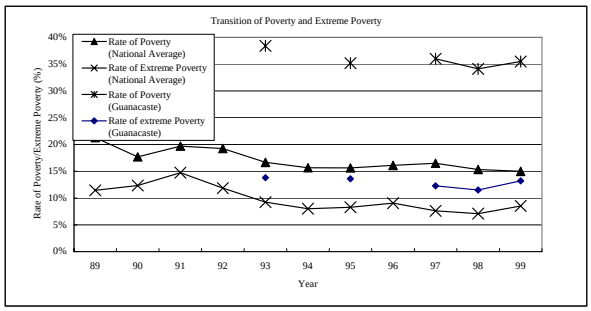
3.1.2 Population

According to the results of the 9th population census carried out in the year 2000 (published 2001), the population of Guanacaste Province was 264 thousand with an increasing rate of 1.9 % (with 3.4% for the urban area and 1.0% for the rural area). Accordingly, the population density has been increasing from 25.3 person/km^2 in 1993 to 28.0 person/km^2 in 1999. The estimated population of the seven districts related to the Study Area at the end of 1999 was about 67 thousand with an average

increasing rate of 2.0 % since 1993. Accordingly, the population density has been increasing from 40.0 person/km^2 in 1993 to 45.2 person/km^2 in 1999. The presumption population in 1998, subtracting the population of urban area in the Liberia city from the presumed total population of seven districts, is approximately 30,000 persons. The average number of members of households in Guanacaste Province had been decreasing from 6.1 person/household in 1993 to 5.7 person/household in 1999.

The number of employment has changed since 1993 at the annual average increasing rate of 1.9% until 1999. During the same period, number of jobs in the tertiary industry had increased 56.4% (with 4.5% of annual average increasing rate), as 28% for the agricultural sector (with -5.8%), and 14.6% for the secondary industry (with -0.9%).

As for poverty, the ratio of the households below the poverty line was 38.4 % in 1993 and it was 35.5 % in 1999 decreasing with an annual rate of 1.3 %. When comparing with the ratio of the national level, the discrepancies are very big, with corresponding figures at 25.9 % in 1993, 23.5 % in 1999, and with the decreasing rate of 3.3 %. The Guanacaste Province ranks the highest in the level of poverty in spite of its endeavors for modernization and its development potentials. There is a mass influx of Nicaraguan laborers to Guanacaste Province, which is one of the reasons for the high ranging of poverty.



(source: EDN)

3.2 NATURAL CONDITIONS

3.2.1 Geomorphology, soils, and vegetation

(1) Geomorphology

The geomorphologic units in and around of the Study Area consists of an ignimbrite plateau, the Tempisque River depression, and the mountainous sector in the Nicoya Complex.

The ignimbrite plateau is located in the northwestern and northeast to east of the Study Area; it embraces the lower parts of the Guanacaste Mountain Range, from La Cruz to Cañas. This undulated morphology reveals a fluvial erosion by the hydrographic system of the Tempisque River over the ignimbrite of "*toba gris*" (gray tuff).

The depression of the Tempisque River, which comprises the majority of the area, is located between the ignimbrite plateau and the Peninsula of Nicoya. This corresponds to the graben area, which is limited by the discontinuous NNO-SSE faults on both sides of its margins. The alluvial surface, which starts from the Monte Galán Farm near the northern border of the area, varies its altitude ranging from 0 m.a.s.l. to 30 m.a.s.l. with 1/600 –1/800 of gradually slope. The widest point of the valley reaches 25 km, with slopes slightly leaned, which are formed by mire and isolated mounts in the western border of the area.

The Tempisque River winds sinuously up to La Guinea and makes a strong turn in the lower waters due to the little gradient and to the presence of numerous isolated mounts; therefore, swamps and "horn lakes" (abandoned curves) are present.

(2) Soil

Most of the Study Area's soil is classified into the Mollisol, Vertisol and Inceptisol order. Mollisol, alluvial originated, spreads along the Tempisque River in the Study Area from NW to SE. Then, on both sides, Vertisol lays out. Additionally, Inceptisol and Alfisol is distributed in the river surroundings, and is Entisol, but in a minor scale. The table presents the area of each soil order:

Area of each soil order in the Study Area

Type	Area (ha)	Percentage (%)
Mollisol	9,943	28
Vertisol	13,114	37
Inceptisol	8,348	24
Alfisol	2,984	9

Mollisol is characterized for being a very fertile soil with abundant organic substances. The main subgroup from the Mollisol order in this area is the Fluventic Haplustoll, which is distinguished for its good drainage, its slight rocky feature, deep soil layer origin, low developed profile, medium to fine texture, and good chemical properties. This kind of soil is appropriate to grow sugar cane, rice, melon, watermelon, etc.

On the other hand, the Typic Pellustert is the predominant subgroup from the Vertisol order. It is characterized for its poor physical and good chemical properties. This type of soil presents a weak degree of drainage during the rainy season and cracks during the dry season. Basically, this type of soil is destined of rice and pasture production.

The Typic Ustropept, of a volcanic origin, is the main subgroup from the Inceptisol order that is present in the Study Area. The horizontal soil varies from 20 cm to 100 cm of depth; in some cases it is rocky. The texture ranges from F and Fa, with a good drainage feature. The topography is flat or vaguely inclined. This type of soil is mainly used for pasture (Classification according to Keys to Soil Taxonomy, 6th edition, 1994).

Costa Rica has a criteria for soils in which the soils are classified into eight categories according to their potential use. Among these, “the type of soil able to maintain the relationship of soil-water-flora in suitable conditions” which are type II and III prevail in the Study Area. These soils represent 58% and 11% respectively of the Study Area. Generally, annual crops require advanced treatments for soil conservation. Nevertheless, 31% of the Study Area surface belongs to the type IV soil, suitable for long-lasting or semi long-lasting crops such as fruit, pasture, etc. That is, 99% of the total is constituted by agriculturally apt soils.

Potential Use the soil in the Study Area

Type	Area (ha)	Proportion (%)
II	20,374	58.2
III	3,797	10.8
IV	10,716	30.6
VII	113	0.3
Total	35,000	100

The land use criteria is summarized as follows:

Type I: The soil does not undergo any limitation as long as it is used for agricultural, livestock, or fishery activities in good relation with the local ecosystem. As a result, the potential use of the soil will not decrease.

Type II: The soil does not undergo any limitation as long as it is used for agricultural, livestock, and forestry activities in good relation with the local ecosystem. Yet, certain crops may cause some reduction in productivity.

Type III: The soil can grow some crops that do not require the usage of any agrochemical, but required to be managed intensively. Besides, soil conservation measures must be taken.

Type IV: The soil requires a great level of conservation treatment and its production is limited to long-lasting or semi long-lasting crops.

Types V to VII: Omit.

4) Other Climatic Factors

Average values of major climatic items are shown below. Lack of required data is compensated by the data of Liberia meteorological station (No. 74020).

Climate Conditions in the Study Area

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Temperature （℃）													
Min.	20.3	20.6	21.3	22.3	22.6	22.6	22.3	22.1	22.0	21.9	21.0	20.3	21.6
Max.	34.1	35.1	36.3	36.8	35.0	32.5	32.6	32.7	32.2	31.9	32.1	32.9	33.7
Ave.	27.1	27.9	28.9	29.6	28.9	27.5	27.5	27.3	27.1	26.9	26.7	26.7	27.7
Sunshine Hours (hour)													
	8.7	8.9	8.4	8.0	6.1	4.9	5.8	5.8	4.8	4.8	6.0	7.9	6.7
Relative Humidity （%）													
	69.5	66.2	65.7	68.4	80.5	87.1	82.8	86.2	89.7	88.9	84.3	78.8	79.0
Wind Velocity (km/h)													
	18.4	20.3	19.2	15.7	10.1	7.4	10.1	9.2	6.6	6.3	8.2	14.3	12.2
	(E)	(E)	(NE)	(E)	(E)	(E)	(E)	(E)	(E)	(E)	(E)	(E)	-

*Wind velocity and direction are from data of Liberia meteorological station. Other items are form Tempisque meteorological station.

Climate in the Study Area is divided into the rainy and the dry seasons. The rainy season is from May to November and the monthly rainfall of that duration counts over 100 mm. Other months count less than 100mm of monthly rainfall and are defined as the dry season. No obvious difference can be seen on temperature through the year. As for wind velocity, values of the dry season show 2 to 3 times of that of the rainy season. Easterly wind is predominant through the year.

(2) Hydrology

1) Tempisque River

The Study Area extends over the midstream basin of the Tempisque River. The Tempisque River originates at the mountain foot of the Orosi Volcano and flows down to the gulf of Nicoya in the Pacific Ocean. Basin area comprises 3,405 km^2 down to the junction with the Bebedero river. The river length is 138 km with 1,487 m of difference the elevation. Twelve major tributaries join to the Tempisque river, five from the right bank and seven from the left bank. Tidal fluctuation affects the river up to around 25km in length from the junction point to the upstream. Ground height on both riverbanks affected by the tidal fluctuation spreads over at the same height of water level at high tide (2.5 to 4.5m).

2) Hydrological Observation

There are 6 principal hydrological stations in Tempisque River Basin. The data of Guardia station, which represents the area, is shown below.

Flowing condition of the Tempisque River

Guardia (Rio Tempisque, A=955.0 km2, 0741901 ICE, 1951-2000) unit; m^3/s

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Ave.	16.80	12.12	9.02	7.61	14.72	30.83	21.51	26.73	48.18	63.07	43.28	22.27	26.34
1/5NE	10.94	7.89	5.87	4.95	9.04	18.93	13.21	16.42	29.59	38.73	28.17	14.49	16.52
1/10NE	9.42	6.79	5.05	4.26	7.19	15.06	10.51	13.06	23.53	30.80	24.25	12.48	13.53
1/5 E	21.16	15.26	11.36	9.59	19.72	41.29	28.81	35.80	64.53	84.47	54.51	28.05	34.55
1/10 E	25.61	18.47	13.75	11.60	23.79	49.81	34.76	43.19	77.85	101.90	65.95	33.94	41.72

Note: NE; non exceedance (being less) probability, E; exceedance probability

The peak flood discharge and minimum discharge is statistically analyzed base on the data observed at Guardia station for 40 years. The results are as shown below.

The peak flood discharge and minimum discharge for each return period (at Guardia)

Return Period	1/2	1/5	1/10	1.20	1/30	1/50	1/100	1/200
Peak Flood Discharge (m^3/s)	442	889	1,267	1,692	1,964	2,335	2,892	3,515
Minimum Discharge (m^3/s)	6.19	4.56	3.79	3.21	2.92	2.59	2.20	1.86

3) Runoff

Average annual rainfall and runoff is the Tempisque river basin at Guardia station is shown below. Runoff ratio is estimated as 0.52 at Guardia station.

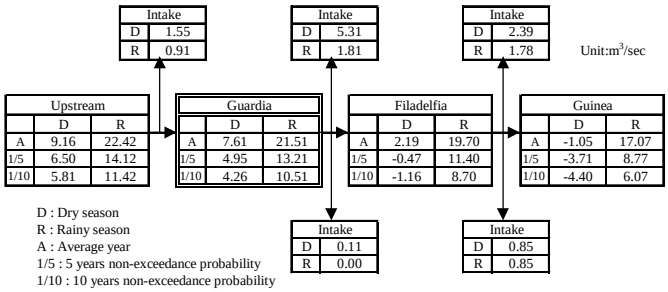
Conditions of Runoff (at Guardia)

Basin Area (km^2)	Average Annual rainfall (mm)	Total Volume of rainfall (MCM)	Annual average runoff (MCM)	Runoff ratio
955.0	1,681	1,605	832.4	0.52

Based on the average annual rainfall of 1,770mm in the Tempisque river basin and the runoff ratio mentioned above, average annual runoff can be estimated as 3,134 MCM for the whole basin.

4) Water Balance on the Tempisque River

Presently, 26 water rights are set up on the main river course of Tempisque River, for utilization of surface flow. Usage for irrigation is the main purpose, and the maximum discharge of such water rights accounts 12.16 m^3/s for the dry season and 5.5 m^3/s in the rainy season. The utilization of water can be illustrated as shown in the figure, based on the flow regime of Guardia, Filadelfia and Guinea hydrological stations. The water rights that are set up exceeded the available discharge during the low water season of the Tempisque River.



Water Right of the Tnpisuque River

3.2.3 Geology and Hydrogeology

(1) Geology

The geological structure in the Study is covered by sedimentary rock irregularly, which were bended and spitted by geodynamic movement based on the Nicoya Complex. And at upper layer of this, the igneous rock and yang non-hard sedimentary rock were formulated.

The Nicoya Complex (Kcn) forms the basis of the Peninsula of Nicoya and is composed by a mixture of igneous, sedimentary and metamorphic rocks and is believed to be an adduct. The quaternaries volcanic deposits correspond to the Bagaces Formation (Ob) that extends over the uphill part of the valley, the plateau, isolated cliffs, and hills located on the northeastern-eastern border of the area. The Bagaces Formation is composed by tuffs, ignimbrites, and andesitic and basaltic vesicular lava. The quaternarian alluvial deposit (Q-al) covers a great section of the area and the granulometric general trend is of alteration of heterogeneous strata of silt, sands and gravel. Furthermore, mixed sediments from lakes and of fluvial-lake origin spread intersperse.

(2) Hydrogeology

1) Hydrogeological Condition

Principal groundwater is located in the alluvial plain of the Tempisque river between the mountain zone composed of the impermeable Nicoya Complex in the west side and hilly zone of semi-permeable/permeable Bagaces Formation in the east. Since the predominance of impermeable layers in the left bank of the Tempisque River, the groundwater shows low productivity. Therefore, hydrogeological study was targeted for the right bank of the Tempisque River. Aquifer varies in thickness from 30 meters to 50 meters showing 80 meters as maximum in the surroundings of the river.

The aquifer consists of sand and gravel with some silty/clayed layers showing heterogeneous character of grain size vertically and horizontally. The aquifer varies from 3 meter to 20 meters in thickness and consists at least of 3 levels; the intermediate and lower levels show high groundwater potential and exist in the depth of 20 to 40 meters, and over 50 meters, respectively. The thickness of aquifers changes in accordance with distribution of the basement rocks. High productive aquifers are found along the old river sites and alluvial fan of tributaries.

Isobath map shows slightly curved contour almost parallel to the Tempisque River direction from NNE to SSE. The excessive groundwater flows only to the Tempisque River because the river course is positioned cutting the continuity of aquifers. Accordingly, the Las Palmas River, witch is one of tributaries of the Tempisque River, does not play a role in the discharge of excessive groundwater. Hydraulic gradient increases as approaching the Tempisque River from 0.2% to 0.8%. Annual fluctuation of statistic groundwater level is almost constant from 1974 to 1980. Moreover, sporadic measurement of statistic water level reveals insignificant change or constant in comparison with existing data. This fact suggests that the pumping volumes still remain as a small amount in comparison with the quantity of natural recharge and influx to the river. Seasonal fluctuation of groundwater levels is high in October, the end of rainy season, and low in April-May, the dry season. This phenomenon suggests that rainfall plays an important role in the recharge of aquifers.

Soil characteristics differ between the northern and southern zones of Filadelfia: sandy soil with good permeability in the former and clayed soil with low permeability in the later. High productive wells, which have specific yield over 5 l/s/m and transmissibility over 400 m^2/day, are generally found in the northern zone.

2) Well Inventory

According to the well inventory made on the basis of available data, approximately 400 wells were found in the Area and its surroundings. More than half the numbers of wells have been drilled by rig. Most of them are 30 – 60 meters in depth and submergible pumps are generally set up. Most of the ground water is pumped up through deep wells. However, monitoring on items such as pump discharge and groundwater levels on the standpoint of water resource conservation is not done. The groundwater is principally used for irrigation, public water supply and agro-industries. Many shallow wells with the depth of under 10 meters, which are not included in the listed wells in the inventory, are also distributed in large numbers. These wells are used for domestic and livestock's purpose. It is concerned that this type of groundwater may have well interference and contamination caused by sewage.

3) Groundwater Recharge

Groundwater recharge in the area comes from natural recharge and return of irrigation water. The Study Area is assumed not to have hydrological connection with other neighboring basins and river systems from the point of hydro geological view.

The natural recharge occurs by means of infiltration of precipitation and partly inundation. According to datum observed by the Study Team, the annual average precipitation at the Hacienda Tempisque

meteorological station located in the center of the Study Area is 1,711 mm during 1953 – 1999. On the other hand, SENARA (2001) uses 1756.3mm as the average amount of precipitation, based on precipitation datum of 48 years. Though the dependence of natural recharge on precipitation differs in the area, 213 km2 (287 km2 according to SENARA, 2001) of the total Study Area excluding the impermeable rocky sectors of the right bank is assumed to obtain the recharge.

Irrigation water comes from groundwater and the river water of the Tempisque. Some portion of irrigation water recharges the aquifers as a resource besides natural recharge. Extracted water volume from river water is shown as follows:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(m^3/s)	11.04	11.04	8.99	7.93	5.50	4.67	4.67	4.67	4.67	4.76	5.49	10.82	
(MCM)	29.6	26.7	24.1	20.6	14.7	12.1	12.5	12.5	12.1	12.7	14.2	29.0	220.8

Source: 3.4.5 Present Condition of Irrigation and Drainage

The area ratio of the irrigated water volume in the right bank can be obtained as follows: 220.8 x 3460/7560 = 101 (MCM). Considering the actual irrigated volume to be approximately 60 % of peak discharge: 101 x 0.6 =60.6 (MCM). Consequently annual irrigation from river water is equivalent to 60 MCM.

Annual pumping volume has been calculated based on a ledger of wells, by verifying extracted discharge, pumping hours by day and pumping period throughout the year.. Total pumping volume is approximately 25 MCM by year of which 19 MCM is used for irrigation. Irrigated volume has been calculated based on the values of the peak if irrigation, therefore the actual volume is assumed to be less than calculated value. Moreover, taking into account of water saving irrigation such as trickle-irrigation, the actual irrigated volume by groundwater is considered to be approximately 80 % of the calculated volume as follows: 19 (1- 0.2) = 15.2 MCM. Finally, the annual volume of irrigation water reaches 75 MCM (=60 + 15) in the right bank of the Tempisque River.

On the other hand, SENARA (2001) is conducting an investigation on the actual conditions of wells that are under operation or planned to be operated, through an extracted monitoring network from records of the wells. The annual pumping volume is calculated from the investigated items; pump discharge, pumping hours by day and pumping period throughout the year.

Based on soil texture, granularity and aquifer character, the infiltration rate of irrigation water to recharge aquifers is considered to be 20 - 40 %. SENARA's technical reports adopt 30 % as an intermediate portion. Consequently, return of water volume corresponds to about 22 MCM (=75 x 0.3 = 22.5).

4) Calculation of Groundwater Recharge

A. Estimation of the Study Team

Two methods have been applied for the calculation of groundwater recharge in the existing studies: one is of hydro-meteorological balance and other is of groundwater hydrograph.

It's impossible to apply methods to calculate the exact amount of groundwater balance in detail, for sufficient data of meteorology and soil groundwater level, etc. are not available. The following methodology refers to the methods indicated in document (SENARA, Consorcio Ingeniería TAHAL Consulting Engineers ltd. y BEL Ingeniería S.A. (1984) p.25-33).

Methodology

The method to determine the recharge volume can be expressed through the following equation:

$$Qi - Qs = \pm \Delta h \, S \, A$$

Where:
Qi = In-flow of Groundwater.
Qs = Out-flow of Groundwater.

Δh = Variation of Groundwater level.
S = Storage Coefficient.
A = Study Area.

Variation of groundwater level (Δh) can be considered as zero, as storage amount does not have drastic changes in long term hydrographical balance. Consequently the equation can be expressed as Qi = Qs.

Qi and Qs are composed of the following elements;

Qi = QR + QI
Qs = QT +QB +QE

Where:

QR = Annual natural recharge
QI = Annual infiltration of irrigation water
QT = Annual Out-flow of Groundwater to the Tempisque river
QB = Annual Pumping volume of Groundwater
QE = Annual Direct Evaporation

That is, the natural recharge can be obtained from out-flow discharge of groundwater to the Tempisque river, pumping volume, direct evaporation and infiltration of irrigation water.

Owing to few wells near the Tempisque River, it's difficult to determine groundwater level and hydraulic gradient. Out-flow of groundwater to the Tempisque river has been obtained with the following method; Calculation of the flow volume through groundwater contour line of 20 m A.S.L. based on data of May-June, 1984 (Fig. 3.1). This contour line is located almost parallel to the river direction with about 1.0-2.5 km toward the west from river course. Back area for water balance can be set as 97 km^2. The contour line +20 was divided into four sections assigned to transmissivity value obtained from neighboring wells and extension of contour lines were obtained for each section. The +25 was also used to calculate the Hydraulic gradient. From these figures, the annual out-flow to the Tempisque River can be calculated as shown in the following table:

Annual Flow

Section	Transmissivity (m^2/day)	Gradient (0/00)	Length (km)	Annual Flow (MCM)
AB	400	4	2.2	1.3
BC	900	6	4.5	8.9
CD	350	7.5	4.5	4.3
DE	800	5.5	7.5	12.0
Total			18.7	26.5

Consequently, annual mean flow to the river is approximately 26 MCM for the balanced area as 97 km^2. The total annual out-flow volume for the right bank (213km^2) can be calculated as 26 x 213/97 57MCM.

The annual pumping volume has been already calculated as approximately 25 MCM. Direct evaporation occurs in swamplands, wells and rivers that occupy approximately 2 km^2 and principally during the rainy season. Total evaporated volume can be considered as 2 MCM. Infiltration of irrigation water has been calculated in the previous paragraph as 22 MCM.

Annual mean natural recharge in the right bank has been calculated as 62 MCM (=57+25+2-22). This recharge volume is equivalent to 291 mm for the area of 213 km^2, which corresponds to 17.0 % of the annual mean precipitation (1711mm) observed at the Hacienda Tempisque meteorological station during 47 years. The infiltrated ratio of annual rainfall shows adequate figures compared to other values mentioned in the previous reports (14.7-25.0%). Moreover, this annual recharge volume is equivalent to 1.97 m^3/s.

B. Calculation of SENARA (2001)

The following method adopted by SENARA is based on the balance of rain infiltration and soil water content, regarding the differences in groundwater recharge and extract as the excess amount of groundwater. The method uses the analytical model for calculating the infiltration of monthly precipitation recently developed by the University of Costa Rica (Modelo Analitico para Determinar la Infiltacion con base en la Lluvia Mensual, Gurther Schosinky & Marcelino Losilla, 1999), and the "Soil Water Content Balance (BHS)" program (Hugo Rodoriguez E, 1990) to obtain the amount of ground water recharge.

For the convenience of development planning, the Study Area was divided into two computational districts regarding differences such as extracted groundwater quantity and soil characteristics.

The calculation of groundwater recharge was done through two steps; the infiltration of precipitation was obtained from existing material (Elizondo J, 1982) and potential evapotranspiration was calculated with the analytical model mentioned above. The calculation method of this model is explained in ANNEX C.

The average annual precipitation used for the calculation was 1756.3mm, which is based on the precipitation records observed at the Hacienda Tempisque meteorological station during 47 years. The monthly potential evapotranspiration was calculated by using the formula of Hargreaves:

$$ETP=0.075 \times RSI \times TMF$$

Where:

ETP = potential evapotranspiration (mm)
RSI = solar radiation represented by the evaporation equivalent
TMF = temperature (F)

According to onsite permeability tests (Elizondo J, 1982), the permeability was 1.53mm/10min (9.18mm/h). Other features obtained from the chart of Amisial/Jegal were; 14% for Field Capacity, 6% for wilting point and 1g/cm3 for density, each of dry weight.

The balance of soil water content was calculated through the Penman-Grincley Method using the BHS program. Two ideas were adopted for the intakes of soil water by plants; the plants intakes soil water by its self, and intakes becomes difficult at the wilting point. In this program, the amount of groundwater recharge was obtained by calculating soil water content through the amounts of precipitation, infiltration and potential evapotranspiration. Also using the two former data, the efflux of surface water was calculated.

The obtained groundwater recharges of the districts are summarized as follows.

Ground Water Recharge

	Northern district	Southern district	Total
Area (km^2)	130	157	287
Recharge (MCM/year)	72.2	43.9	116.1

C. Comparison of Recharge Quantities

Though it is natural to think that groundwater recharge obtained in different basis and methods will differ significantly, the quantities indicated above showed adequate figures, representing 17.0% and 15.9% of the average annual rainfall, respectively. Yet, in the progression of the study, it is still necessary to detail the figures through enhancement/maintenance of basic data, and clarifying/ improving the calculation process.

3.2.4 Natural Environment

(1) Natural Environment of the Tempisque River Basin

There are three nature conservation systems for the Tempisque basin, including the Guanacaste conservation area. A part of the Guanacaste conservation area, which is located in the upper stream of the area is designated as a World Heritage (natural heritage) in Dec. 1999. In the lower stream of Tempisque river is the Palo Verde National Park registered to the Ramsar Convention. In this area, are wetlands abundant of wild life. Areas such as National Parks, Reserves, Wildlife National Refuges, Wetlands, Protected Forests, and others occupy 20% of the basin with the area of 770km2. The form of forests of the Tempisque river basin is Bio-climatologically varieties (mountainous rain forests – low mountain rain forests – low mountain wet forests – tropical rain forests – tropical wet forests – tropical dry forests), and rich of biodiversity. According to the available data of 1998, there are 135 species of mammals (12 endangered), 426 species of birds (29 endangered), 57 species of reptiles (1 endangered), 23 species of amphibians and 10 species of fish living in the midstream basin of Tempisque River. There are also 6 species reported to have fear of extinction such as the Cocobolo (Dalbergia retus). MINAE has been investing US$ 1.5 million/year for the management of the basin and has been practicing activities such as afforestation. However, activities are limited and do not embrace the whole basin area. The Study Area is located in the middle basin of the Tempisque River. Forests in the Tempisque River Basin remain mainly in the mountain areas, upstream of the Study Area, while small hills are principally exploited for cattle raising. In the Study Area, forests represent only 4%; the rest of the land is used for agriculture or other more profitable activities; thus the number of flora and fauna species is being diminished.

(2) National Conservation Areas System

The National Conservation Areas System (SINAC; Sistema Nacional de Areas de Conservacion) is a specific method of Costa Rica for natural conservation. SINAC is a system covering the whole country for the enforcement of policies aiming for nature conservation and sustainable development. To be specific, under the supervision of MINAE, the system transfers the authority of bio-diversity conservation projects to the conservation areas having jurisdiction over the region, and enables the participants to control the projects in sustainable manners. There are 11 conservation areas (CA) including the Coco Island as indicated below.

Marina Isla del Coco (2,309ha, the whole area designated as conservation area)
Guanacaste (347,849ha, 114,079ha of the area designated as conservation area)
Tortuguero (305,012ha, 126,942ha of the area designated as conservation area)
Arenal-Huetar Norte (647,937ha, 70,682ha of the area designated as conservation area)
La Amistad Caribe (620,731ha, 227,164ha of the area designated as conservation area)
La Amistad Pacifico (631,916ha, 182,546ha of the area designated as conservation area)
Osa (422,008ha, 145,492ha of the area designated as conservation area)
Arenal (261,873ha, 78,338ha of the area designated as conservation area)
Pacifico Central (547,731ha, 97,581ha of the area designated as conservation area)
Tempisque (746,339ha, 63,402ha of the area designated as conservation area)
Cordilla Volcanica Central (566,108ha, 141,352ha of the area designated as conservation area)

As indicated, the nature conservation areas of Costa Rica sum up to 1,310,301ha, which represents 25.4% of the nation. The natural conservation areas are categorized as follows:

Natural Conservation Area in Costa Rica

Category	Number of areas	Total area	Percentage of land in the nation
National Parks	25	567,852ha	11.0%
Reserves	8	21,432ha	0.4%
Wildlife National Refuges	49	175,524ha	3.4%
Protected Forests	11	284,133ha	5.5%
Protected Zones	31	163,714ha	3.0%
Wetlands	14	88,289ha	1.7%

Category	Number of areas	Total area	Percentage of land in the nation
Areas of Absolute Protection	2	1,330ha	0.0%
Other Conservation Areas	2	7,561ha	0.1%
Land in Conservation Areas Owned by Farmers	9	8,501ha	0.2%

The Study Area is located under the "Guanacaste Conservation Area System" and also in the "Tempisque Conservation Area System" under the "National Conservation Areas System". The areas protected by law in the Study Area are the shoreline areas of the Tempisque River (in range of 10 to 100 meters from the shore) designated as the "Riberino Zapandi Wetland". Furthermore, there is the "Estación Exp. Horizontes" located about 10 km upstream of the Tempisque River. For other protected areas, there is the "Palo Verde National Park" approximately 6 km east of the Study Area, "Lomas De Barbudal Biological Reserve Area" on the northern side of Palo Verde National Park and "Mata Redonda Wildlife Refuge Area" and "Palustrino Corral De Piedra Wetland" on the southern side of the Palo Verde National Park. In 1992, Palo Verde National Park was listed in the International Wetlands Convention (Ramsar Convention, Ramsar, Iran, 1971). The "Estación Exp. Horizontes", along with the "Santa Rosa National Park" spreading in the northern area, is included in the Guanacaste conservation area, which was registered in the "Treaty on Global and Cultural Heritage" in 1999. As above-mentioned, there are numerous conservation areas surrounding the Study Area though few are located within. Videlicet, the Study Area is the only area capable for agricultural development.

(3) Flora and fauna in the Study Area.

- Flora

The flora of Costa Rica is categorized as common, endangered (seen in particular location), endemic and exotic. The endangered species of flora that are assumed to exist in the midstream basin of Tempisque River are as follows:

Guayacan Real	*Guaiacum sanctum*
Caoba	*Swietenia macrophylla*
Caoba	*Swietenia humilis*
Cristobal	*Platymiscium parviflorum*

There are no endangered species in the Study Area or its surroundings. However, there are numerous regulations upon deforestation. There are numerous wetlands and swamps in the Study Area and its surroundings, particularly in the down stream of the Tempisque River. Manglobes and submerge forests are seen in the shorelines of these areas. The Study Area is developed for agricultural uses e.g. pasture and sugar cane, and the remaining forests are only seen in places designated from development, and in the shorelines legally protected as the "Riberino Zapandi Wetland". These forests represent 4% of the Study Area, and consist of two sectors; Sector A (Tropical Dry Forest) and Sector B (Transitional Forest: from Rain Forest to Tropical Dry Forest). The total of rivers and submerged areas hold 880ha of the Study Area.

Sector A consists of 4 patches of Tropical Dry Forest, mainly covered by bushes with vines and thorns, and by the following adult trees: Guanacaste, Tempisque, Cenizaro, Cedro, Roble, Guacimo, Laurel, Ceiba, Alcornoque, Sabana, Papaturro, Jicaro, Panama, Poroporo and others. Sector B consists on 27 patches of Transitional Forest, where the following trees prevail: Guanacaste, Cedro, Jobo, Madrono, Laurel, Cenizaro, Almendro de Montana, Guacimo, Espavel, Accituno, Papaturro, Ficus, Madero Negro and Sura. The "Riberino Zapandi Wetland" and the flooded areas conform an area of 880ha with Uva de Montana, Guacimo, Cornizuelo, Papaturro and others.

- Fauna

The endangered species of fauna that are assumed to exist in the midstream basin of Tempisque river are as follows:

Mammals

Name of species	Scientific name	Name of species	Scientific name
Mono Colorado	*Ateles geoffroyi(3)*	Caucel	*Felis wiedii(2)*
Mono carablanca	*Cebus capuccinus(3)*	Danta	*Tapirus bairdii(2)*
Grison	*Galictis vitata(2)*	Chancho de monte	*Tayassu pecari(2)*
Puma	*Felis concolor*	Vampiro	*Vampyrum spectrum(3)*
Jaguar	*Panthera onca(2)*	Ardilla chiza	*Sciurus deppei(3)*
Manigordo	*Felis pardalis(2)*	Rata	*Reithrodontomys gracilis(3)*

Source: Plan de Accion para la Cuenca del Rio Tempisque Diagnostico Funcional II, 1998

Birds

Name of species	Scientific name	Name of species	Scientific name
		Gavilan ranero	*Geranospiza caerulescens(3)*
Agami	*Agami agami(3)*	Gavilan caracolero	*Rostramus sociabilis(3)*
Avetoro	*Botaurus pinnatus(3)*	Aguilillo penachudo	*Spizaetus ornatus(2)*
Mirasol	*Lxobiru exilis(3)*	Halcon peregrino	*Falco peregrinus(3)*
Galan sin ventura	*Jabiru mycteria(3)*	Halcon collarejo	*Micrastur semitorcuatus(3)*
Espatula rosada	*Ajaja ajaja(3)*	Pavon	*Crax rubra(3)*
Pato real	*Cairina moschata(3)*	Pava crestada	*Penelope purpurascens(3)*
Pijije canelo	*Dendrocygna biocor(2)*	Polluela pechiamarilla	*Prozana flaviventer(3)*
Pijije cariblanco	*Dendrocygna viduata(1)*	Lora nuca amarilla	*Amazona auropaliata(3)*
Pato enmascarado	*Oxiura dominica(3)*	Lapa roja	*Ara macao(2)*
Zoplilote rey	*Sarcoramphus papa(3)*	Sorococa	*Otus guatemalae(3)*
Gavilan cienega	*Busarellus nigricollis(3)*	Colibri de manglar	*Amazilia boucardi(3)*
Gavilan coliblanco	*Buteo albicaudatus(3)*	Pajaro campana	*Procnias tricrunculata(3)*
Aguilucho	*Buteogallus urubitinga(3)*	Vireo de manglar	*Vireo pallens(3)*
Gavilan piquiganchudo	*Chondrohierax uncinatus(3)*	Chiltote	*Icterus pectoralis(3)*

Source: Plan de Accion para la Cuenca del Rio Tempisuque Diagnostico Funcional II, 1998

Reptiles: crocodile（Crocodilus acutus, identified in field survey）
Fish and insects: not classified

The wild fauna as well as wild flora have been decreasing in the Study Area. The habitat areas of mammals, birds, reptiles, Fish and insects are lost, by such reasons of hunting, capture and persecution. Species such as the following were observed in the area: Zanate, Urraca, Copetuda, Palomas, Garzas, Soldatitos, Queques, Pecho Amarillos, Tijos, Garzones and Patos agujas for birds, Garrobos, Lagartijas, Chivalas, Iguanas Cocodrilos, Boas for reptiles, monkeys, Zorrillow for mammals and species of aquatic insects. The only endangered specie identified in the midstream basin of Tempisque River during the field survey was the “Crocodrilo acutus”.

(4) Water Quality

a. Existing Data

There are several kinds of existing data describing the water quality of Tempisque River. In 1997, a survey on the numbers of Coliform groups, chromaticity and turbidity were conducted. Surveys on 11 items including sulphate ions, sodium ions and total carbonic acid, were conducted for the total of twelve times during 1987 - 1991 at the survey point of Guardia. Also surveys on the same items were conducted for 10 times during 1980 – 1981 at the survey point of Guinea. At the point where the agricultural effluent from the Tamarindo Agricultural Developement Area flows in to the reservoir where it is treated, items such as agrochemical elements (38 items, including 2,4-D) were analyzed. These datum are listed specifically in Appendix D.

- Data Differences in Relation with Different Survey Periods

Measurements of the survey points of Guardia and Guinea characterizing the rainy/dry seasons, along with measurements in the periods characteristic of the survey points are shown below. Naturally, the density of items in the dry season exceeded that of the rainy season by three times at Guardia and two

times at Guinea. On the other hand, mineral ion contents at Guardia increased at the rate of 6% during 1987 to 1991, while at Guinea, the increase of 4% was observed during 1980 to 1981. These results indicate the progress of development of the area surrounding Tempisque River.

Comparison of rainy/dry seasons at Guardia Survey Point

Date	PH	EC	Alka-linity HCO_3	Chlo-rine Cl^-	Sul-phate SO_4^{-2}	Silica SiO_2	Sodium Na^+	Pota-ssium K^+	Calcium CA^{+2}	Magne-sium Mg^{+2}	Total carbonic acid $CaCO_3$
		μ/cm	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L
Dry season 25/04/87	7.61	245	83.0	30.9	18.3	88.2	32.3	7.70	11.7	8.90	65.8
Rainy season 25/08/88	7.00	110	47.4	5.1	12.5	36.6	4.5	1.60	5.5	2.33	37.0
Dry season / Rainy season	-	2.2	1.8	5.8	1.5	2.4	7.2	4.8	2.1	3.8	1.8

Average rate of Dry season / Rainy season: 3.3

Comparison of rainy/dry seasons at Guinea Survey Point

Date	Temp.	PH	Alka-linity HCO_3	Chlo-rine Cl^-	Sul-phate SO_4^{-2}	Silica SiO_2	Sodium Na^+	Pota-ssium K^+	Calcium CA^{+2}	Magne-sium Mg^{+2}	Total carbonic acid $CaCO_3$
	℃		Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L
Dry season 17/04/80	28.5	8.25	88.8	13.1	11.7	70	26.2	5.9	17.8	6.6	71.61
Rainy season 09/09/80		7.35	40.6	13.4	16.7	59	5.5	2.8	10.0	3.4	38.96
Dry season / Rainy season	-	-	2.2	0.0	0.7	1.2	4.8	2.1	1.8	1.9	1.8

Average rate of Dry season / Rainy season: 1.8

Comparison of surveyed time period at Guardia Survey Point (Dry season)

13/02/91 ／ 24/01/87	PH	EC	Alka-linity HCO_3	Chlorine Cl^-	Sulphate SO_4^{-2}	Silica SiO_2	Sodium Na^+	Pota-ssium K^+	Calcium CA^{+2}	Magne-sium Mg^{+2}	Total carbonic acid $CaCO_3$
		μ/cm	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L
24/01/87	7.36	195	65.3	23.9	22.7	77.3	22.1	5.50	14.3	5.10	62.9
13/02/91	7.95		76.9	29.7	19.4	80.2	24.6	5.91	14.9	5.24	61.8
1991/1987	-	-	1.18	1.24	0.85	1.04	1.13	1.07	1.04	1.03	0.98

The average rate of increase from 1987 to 1991: 1.06 (Total increase of 6%)

Comparison of surveyed time period at Guinea Survey Point (Dry season)

03/02/81 ／ 17/04/80	PH	Alkalinity HCO_3	Chlorine Cl^-	Sulphate SO_4^{-2}	Silica SiO_2	Sodium Na^+	Potassium K^+	Calcium CA^{+2}	Magnesium Mg^{+2}	Total carbonic acid $CaCO_3$
		Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L
17/04/80	8.25	88.8	13.1	11.7	70	26.2	5.9	17.8	6.6	71.61
03/02/81	8.00	69.7	24.4	15.7	67	18.5	6.0	15.8	5.9	68.4
1981/1980	-	0.74	1.86	1.34	0.96	0.71	1.02	0.89	0.89	0.95

The average rate of increase from 1980 to 1981: 1.04 (Total increase of 4%)
Data source：Instituto Costarricense de Electricidad Datos de Calidad de Aguas, Sistema Hidromet, 1987-1991

- The surface runoff from the Tamarindo Agricultural Development Area

Two reservoirs were installed on the east and west of the Tamarindo Agricultural Development Area as treatment facilities of agricultural effluents. Surveys on water quality was conducted for three times in the dry seasons during Dec. 2000 - May 2001. The water sampled from the entering point of the reservoirs were analyzed for the following 38 items. Moreover, waters from the exit point of the reservoirs were not analyzed. The levels of agro-chemicals of all samples were below detection limits.

Ingredient Analized

Item analyzed	Item analyzed	Item analyzed
Clorotalonil	Deltametrina	Tiabendazol
Captan	Oxifluorfen	Metamidofos
Diuron	Diclorvos	Carbofuran
Endosulfan α and β	Acefato	3-hidroxicarbofuran
Bromacil	Dimetoato	Methiocarb
Clorpirifos	Profos	Oxamil
Triadimefon	Terbufos	Carbaril
Imazalil	Diaxinon	Foxim
Bifentrina	Metalaxil	Etion
Tetradifon	Forato	Malation
Permetrina	Fenamifos	Monocrotofos
Cihalotrina	Cipermetrina	Cadusafos
Cipermetrina	Metil-paration	-

At the same time, items such as alkalinity, BOD (Bio-chemical Oxygen Demand), COD (Chemical Oxygen Demand) were measured. For alkalinity, observed levels of the reservoir located on the Western side were about the same as that of the Tempisque River at the dry season. However, the alkalinity of the reservoir on the eastern side were 1.3 to 1.5 times more, indicating that higher rates of contamination is occurring. For BOD, the levels were 2 - 9mg/L. These levels indicating values under 10mg/L, Refers to the Japanese environmental quality standards for water pollutants, as “levels not causing unpleasantness to the daily life of citizens”, it may be said that these levels do not indicate the progress of contamination by organic substances. On the other hand, the values of COD varied from 20 to 50mg/L. In comparison with the Japanese standards for agricultural water, of under 6mg/L, and the assumed values of waste water from dairy plants being 50 – 200mg/L, the indicated values of the reservoir may be said to be highly contaminated by chemical contaminants.

b. Data Obtained in This Study (conducted in 2001)

Water quality analyses were conducted for 13 existing wells, 6 points of rivers and canals, and 7 newly excavated observation wells (3m depth) for 4times in 2001 (two times in Feburary, once in July and once in September). The analyses were done for four times. The quality of water in the existing wells turned out to be clean only in the Ocote well, 3 km upstream from Filadelfia; the other 12 wells were polluted with microorganisms. The most polluted well was found in Bolsón, in the downstream part of the Study Area. The well presented a constant level of nearly 350mgCaCO3/L. Electric conductivity reached 848 μs/cm, which is comparable to the water quality of polluted rivers. In addition, the levels of fecal coliformes and common bacteria exceeded the standards.

The cleanest water quality was found in La Guardia; on the contrary, in El Viejo, approximately 25 km downstream of La Guardia, the concentration of pollutants were ten times greater than La Guardia during the dry season due to the incoming bacteria and coliformes. The canal that collects the drained waters from the sugar cane plantations was also polluted, reaching high levels of sulfur and turbidity; five or six times bigger than those found in the waters of Tempisque River.

The waters of all observation wells recently drilled in the Palo Verde National Park and its surroundings, were polluted by bacteria and coliforms. For the points in Palo Verde National Park, where surface water flows in from the North-West and North-East (P.V. Bocana) respectively, the electric conductivity presented levels of 1,400 - 15,000 μS/cm, which are levels barely seen even for surface waters; this suggests high contamination of mineral elements. Particularly, at the point where surface water flows in from the Northeast, water showed strong acidity of pH 3,5 (summer); indicating an advanced degree of pollution. Conversely, during the rainy season, the concentration is reduced to one tenth of the concentration in summer due to dilution. On the matter of agrochemicals, values of the nine monitored points were under the limit of detection.

c. Comparison of Existing Data and Data Obtained in This Study

- Comparison of data obtained at the Tempisque River

In the results of the data observed in this study, the Tempisque River was polluted by coliform groups, as indicated in the survey of 1977. For La Guardia, the data obtained in this study indicated the increase of Silica, and decrease of total carbonic acid while the values of other items were stable. The increase of silica suggests the increase of soil erosion in the upper streams, for the substance is a constituent of soil.

- Surface outflow from the Tamarindo Agricultural Developement Area

The outflow from the Tamarindo Agricultural Developement Area flows into reservoirs and arrives to the P.V. Bocana approximately 2km downstream where water quality analysis were done in this study. The comparison of data obtained in this study and existing data observed in simultaneoius periods are shown below. According to these results, the levels of agrochemicals at the entering points of the reservoirs and P.V. Bocana were below the limits of detection. However, for the items, calcium, magnesium, sodium, phosphorus, chloride, nitrogen, sulphides and BOD, the levels observed at P.V. Bocana were extremely high compared to the entering points of the reservoirs. Especially for sulphide and magnesium, which values were 2,000 and 300 times more than that of the entering points of the reservoirs, respectively. It may be assumed that agricultural effluents contaminated the water in the 2km section between the reservoirs and P.V. Bocana.

Comparison of existing data and data obtained in this study

		Existing data Observed in 14, Mar. 2001		Data obtained in this study Observed in 20, Feb. 2001
Items analyzed	Units	Reservoir (Western side)	Reservoir (Eastern side)	P.V. Bocana
Agro-chemicals		ND	ND	ND
Total carbonic acid	HCO_3-Mg/L	83	107	＜10
Calcium (Ca)	Mg/L	13.4±0.6	10.8	620±20
Magnesium (Mg)	Mg/L	4.4±2	4.6	600±100
Sodium (Na)	Mg/L	10±2	16±2	3300±500
Potassium (K)	Mg/L	1.7	1.7	81±2
Chloride (Cl)	Mg/L	9.4±0.5	7.2±0.5	1670±400
Nitrogen (N)	Mg/L	<0.5	<0.5	29±1
Sulfur (S)	Mg/L	3.7±0.5	2.7±0.5	7200±400
BOD	Mg/L	9±1	3.3±0.5	48±7
COD	Mg/L	40±20	50±20	90±20

ND: Below limits of detection

(5) Agrochemicals

The agrochemicals used in the Study Area and its surroundings are some 30 types of herbicides, 20 types of insecticides, and 10 types of fungicides. Among them are some products that the Ministry of Agriculture of the United Kingdom has annulled their registration through its Committee for Agrochemical Security. These are Carbofuran and Diazinon, as well as Clorpirifos, an organic phosphorus insecticide prohibited in the USA. Paraquat, an herbicide with extremely high residual property, which is assumed to be related to the Parkinson disease, is also used. The management of agrochemicals subjected to such problems must be further considered. The following chart shows the estimated annual selling amount regarding the principal agrochemicals in and around the Study Area:

Assumed Annual selling amount of Principal Agrochemicals in and around the Study Area (Unit: t)

	Herbicides	Insecticides	Fungicides
Sugar Cane	108.9	24.2	0
Rice	71.5	43.3	39.3
Melon	10.0	38.5	56.0
Vegetables	1.0	1.6	7.3
Mango	1.2	2.3	3.5
Total	192.6	109.8	106.1

According to these figures, the main agrochemicals used for farming are, herbicides for sugar cane, herbicides and insecticides for rice and fungicides for melon. Generally, fungicides are shortly residual and represent a reduced burden for the environment. Following are the agrochemicals that might negatively affect the environment, highly residual and/or toxic, and has a relatively high application volume. They are presented in order of priority according to the relating crop:

Sugar Cane: Ametryne (Herbicide) > DCMV (Herbicide) > Terbutryne (Herbicide) > Metribuzin (Herbicida)
Rice: Oxadiazon (Herbicide) > Pendimetalin (Herbicide) > Oxiflourofen (Herbicide)
Melon: Dimethate (Insecticide)

Among the agrochemicals used in the Tempisque River, the following chart includes the data on standard application volume per surface unit for those that hold the greatest toxicity for fish and mollusks due to its residual properties, in comparison with Japanese data. According to this chart, in Costa Rica the usage volume per surface unit of some herbicides are from 0.5 to 8,3 times greater than the doses applied in Japan. For instance, Oxadiazon is an herbicide for rice with extremely high residual properties and toxicity for fish; its doses in Costa Rica exceeds Japan's 1,3 to 8,3 times. Therefore, it is necessary to procure the best agrochemicals application method, considering the climate of the Study Area.

Standard Application Volume of Agrochemicals

Products	Spanish Names	Common Names (in English)	Crops	Standard Usage （component kg/ha）		(b)/(a)
				Japón (*world) kg/ha (a)	Costa Rica kg/ha (b)	
Herbicides	Terbutrina	Terbutryn	Sugar cane	*1-2	2,0	1,0~2,0
	Diuron	DCMU	Sugar cane	0,8-1,2	2,0	1,6~2,5
	Ametrina	Ametryne	Sugar cane	2,5-3,75	2,0	0,5~0,8
	Metribuzin	Metribuzin	Sugar cane	0,5-1	1,0	1,0~2,0
	Oxiflouren	Oxyfluorofen	Rice	*0,1-1,0	0,6~2,5	2,5~6,0
	Oxadiazon	Oxadiazon	Rice	0,6	0,8~5,0	1,3~8,3
	Pendimetalin	Pendimetalin	Rice	0,6-1,2	0,8~2,5	1,3~2,1
Insecticides	Clorpirifos	Chlorpyrifos	Rice	2,7	1,5	0,6
	Dimetoato	Dimethate	Rice	0,43-0,86	0,5	0,6~1,2

*: World´s standard application volume, for these products are not registered in Japan.

(6) Problems concerning Palo Verde National Park

Environmental problems indicated by the Palo Verde National Park concerning the environmental impact by existing irrigation development in the surrounding areas are sermonized below:

For natural environment;

a. Deforestation and Rupture of Forest Areas;

There are two biological runners “La Mula” between the reserves of Lomas de Barbudal and Palo Verde National Park, each with the extension of 4km and the width of 2km, planned in the Phase1 and 2 of the Arenal-Tempisque Irrigation Project. By the point of Nov. 2001, a part of these biological runners were deforested for the area of approximately 3km long and 40m wide. This was in result of the expansion of the west canal as the extension of the Bagatzí Canal propelled by capitals of private enterprises in the Phase3 of the project. Though countermeasures such as bridges and transition ropes for the migration of animals are planned after the completion of the west canal, it is obvious that migration of animals between these forests will be obstructed.

b. Pollution of Water;

There are 18,000ha of irrigated land located in elevation higher than the Palo Verde National Park, developed by the Phase1 and 2 of the Arenal-Tempisque Irrigation Project. These are the Cabuyo sub area (4,541ha), Piedras sub area (7,070ha) and Cañas sub area (6,060ha), and newly used chemical substances such as agrochemicals and fertilizers are washed away from these fields and act as sources of water pollution.

c. Soil Erosion;

As aforesaid, the sub areas of Cabuyo, Piedras and Cañas were developed for agriculture. In the rainy seasons, the eroded soil flows out of the area and into the Palo Verde national park.

d. Use of Agrochemicals;

As aforesaid, agrochemicals from Cabuyo, Piedras and Cañas will flow in to the Palo Verde national park, though in a level lower than limits of detection.

e. Problems concerning Wildlife (extinction, immigration, diseases and intoxication);

Conditions of habitat will be constraint by changes of vegetation due to development of the sub areas of Cabuyo, Piedras and Lajas located in the surroundings of Palo Verde national park. This will lead to the elimination and/or migration of the animals feeding on these plants. Furthermore, with loads brought in by humans acting as mediation, bacterial diseases and intoxication may spread.

f. Recharging of Water Resources;

On the other hand, as favorable effects for the natural environment. The discharge of irrigation water from Arenal Lake to Corobicí and Pedras River plays the main role in recharging groundwater during the dry season, when Palo Verde National Park lacks of surface water.

For social environment;

g. Intoxication of People Using Agrochemicals;

In the sub areas of Cabuyo, Piedras and Lajas located in the surroundings of Palo Verde national park, there are intoxication accidents due to the inattention on farmers using agrochemicals.

h. Accidents Caused by Crocodiles;

Likewise to intoxication, accidents caused by large animals such as crocodiles occur among the farmers due to inattention.

i. Field Fire;

Likewise to intoxication, field fire occur due to the inattention of farmers. Though the Points mentioned above are expected to be occurring in the area, the evidence substance to these tendencies cannot be observed clearly through the study. Furthermore, as there are long distance between the proposed project area of the study and the Palo Verde, it is difficult to consider that the big impact from the proposed project, as same impact as at present can be occurred. However, from the viewpoints of science, as there are several obscure points for the Tempisque river flowing into Palo Verde National Park, it shall be necessary to carry out the monitoring.

(7) River Maintenance Flow

As mentioned in section 3.2.2, for the average monthly flow discharge at Guardia of the Tempisque river in the Study Area, the maximum of that is 63 m^3/s (October) and Minimum of that is 7.6 m^3/s (April). The condition of average flow discharge observed in April in Tempisque is shown below.

Average flow of Tempisque River in April (m^3/s)

Section (distance)	Upper part – Guardia (7km)	Guardia – Guinea (30km)	Guinea – Liberia river (10km)	Liberia Riv. - SENARA canal (5km)	SENARA canal - Para Verde (5km)
Discharge (site)	7.6 (Guardia)	3.7 (Guinea)	1.7 (Liberia river)	0.9 (SENARA canal)	0.9 (Para Verde)

The figures in the chart above are the monthly averages of April, while stochastically, no water flow for approximately 40 days may occur at SENARA canal once every two years. This state is derived by the preferential of economic activity, which lead to the utilization of water of the Tempisque even in the dry season, leaving none for the river. Formerly, about 50 years ago, constant river flow of the Tempisque was preserved in the dry season of about the amount of that presently seen in the upstream

area. At this time, animals and plants living dependently on the existence of river flow were seen in the area. It is assumed that at the present state of the SENARA canal station, the following hazards may occur. However, it should be noted that there are no drastic environmental changes in the area upstream of SENARA canal station, or in the whole area in the rainy season where water flow exceeds the amount of water utilized.

- At the SENARA canal station, the rupture of the river occurring at the probability of once every two years may lead to isolation of species. The continuation of this state may affect the natural environment. Present findings cannot declare that there are no effects for the state is relieved in the rainy season.
- Extinction and decrease at the probability of once every two years, of benthos and creatures such as small fish feeding on them, leading to the parting of birds feeding on such creatures in the area. The continuation of this state may affect the natural environment. Though the environmental load acceptable by this area is not declared by present findings, there is no hope for sustainable economic growth without the load being controlled in the natural capacity.
- The deterioration of suitable conditions of landscape and water quality at the probability of once every two years. When the waters of the area near SENARA canal station are polluted, the number and kind benthos will be constraint. Consequently, effect on natural environment may occur as for the dehydration of the riverbeds. Suitable river environments require preservation of river flows at a certain level with certain water quality. Without suitable river environments, there is no hope for sustainable economic growth in the area.

Therefore, it is necessary to keep the minimum maintenance river flow from the viewpoints of landscape, protection of wild life and to maintain the clean water flow.

(8) Damage on fishery of the Nicoya gulf

Investigation on the damage on fishery in the Nicoya gulf were conducted through such methods of hearing investigation at universities and information retrieval on local news papers.

a. Hearing Investigation at Universities

Hearing investigation was done to numerous experts on agrochemicals and fishes of the Costa Rica National University. The consolidated information are as follows:

- The information such as “the fish died of agrochemicals” are probably arbitrary
- Though death of fishes may be caused by illegal renounce of agrochemicals, the news on mortality of fishes is about fish farming and is not involved with the Nicoya gulf
- Foremerly, the damage to the fishes of the mouth of Tempisque were caused by the gold mine in Abangares of the Juntas district, 20km towards San Jose from Cañas. The news papers also reported that the damage was coursed by the mine. The mine does not exist anymore.
- Relations between agrochemicals and the death of fishes in the Nicoya gulf is not scientifically acknowledged.

b. Information Retrieval on Local Newspapers

Information retrieval were done concerning the relation between agrochemicals and the death of fishes in the Nicoya gulf, on the news papers of Costa Rica and articles owned by the library of Costa Rica National University. Such information was not found in nether of the sources.

c. Obtained Articles

The following article was obtained from SENARA.

“An Economic Model of the Arenal-Tempisque Watershed”(By: Yanjin Chenand Ujjayant Chakravorty, 2000)

Though the article was on the decrease of fishery profits (30.14 million dollars to 18.35 million

dollars) due to the increase of irrigated area in the upper basins of Tempisque river (20,000ha to 40,000ha), datum concerning the relation between agrochemicals and the death of fishes in the Nicoya gulf were not used due to its low reliability.

Consequently, it may be said that there is no scientific evidence on the relation between agrochemicals and the death of fishes in the Nicoya gulf.

(9) Cultural Heritage to be Considered

Though there are no cultural heritage found in the Study Area, the existence of buried cultural assets are reported adjacent to the Tempisque River. The details are listed in Appendix D. There is also a museum anteroom owning a collection of stone implements found near Filadelfia. In the surroundings of the Study Area, there are "Nacascolo" which is the ruin of residence of the indigenous, and "Guaitil" which is the cultural heritage and religious meeting place of scheduled meetings of the indigenous.

In the Guanacaste there are the following cultural heritages

"Reserva Indigena Matambu";	the concession of the indigenous
"Las Pilas" ;	the ruin of residence of the indigenous located by the sea shore
"El Hacha" and "Las Huacas";	the ruins of residences of the indigenous located in the mountains
"Cerro Caballito";	the ruin of residence of the indigenous residing in caves
"Lago de Cote" ;	cultural heritage and religious meeting place of the Mosquito faction, used for scheduled religious meetings of the indigenous
"Santa Rosa" ;	the ruin of the battle against American filibuster (1856). Ground break ceremony for reconstruction was held at the memorial day of triumph in Mar. 2002, after 2 houses being burnt down by arson.
Religious architecture;	Early Christian church of colonial style located in Nicoya city.

3.2.5 Actual Situation of Floods

Most of the Study Area is categorized in potential flood damage zone according to the Guanacaste inundation potential hazard map (MAPA DE AMENAZA POTENCIAL DE INUNDACION, GUANACASTE), compiled by CNE (National commission of emergency; COMMISION NACIONAL DE EMERGENCIAS).

(1) Factors Bringing Inundation Damage

In the Study Area, following aspects can be considered as the major factors that lead to inundation, and combination of these factors generate inundation damages.

1) Rainfall

The Study Area is influenced by tropical depression and cyclones bringing local rainstorm and/or continuous rainfall during the rainy season. Generally, rainfall during the rainy season (especially from May to August) occurs by local depression. The hyetograph of such rainfall shows only one peak and flood duration caused by such rainfall is relatively short. In the latter half of rainy season from September to November, concentrated and continuous rainfall occasionally occur due to outbreak on a series or independent of cyclones, running wild and/or in stagnation. Continuous rainfall leads to a range of flood runoff peak. Inundation damages occur under these conditions in the Study Area.

2) Topography

Flood runoff in the Tempisque River Basin is finally evacuated to the Gulf of Nicoya through the Tempisque main river course and its tributaries such as Liberia, Palmas-Bolsón and Cañas-Charco rivers. At the surroundings of the confluence with bolsón and Charco, and below the confluence point with Charco River, the river course of Tempisque River runs through the alluvial plains with hills

located intersperse like islands. Those river courses develop only low-water flow section. Elevation of both riverbanks is 3.5 to 4.5m and is as the same height of the high tide. Many wetlands are developed on both riverbanks because excess water flows over the riverbank during the floods. Riverbank forest consisting of mangrove and local species is also developed at the downstream reach of Tempisque river. Those forests, however, obstruct drainage by gravity when inundation is occurred in the downstream reach of the basin.

3) Tidal Fluctuation

The downstream reach of the Tempisque River is affected by the tidal fluctuation of the Nicoya Gulf of the Pacific Ocean. Tidal fluctuation affects the river around 25km in length from the junction point with the Bebedero River to the short-cut portion of the river called as "SENARA canal". Tidal fluctuation also affects Bolsón and Charco rivers around 3 to 4 km from their junction point with the Tempisque river. With these conditions, flood runoff is stagnant and expands the inundation area when flood occurs during the high tide. High tide level ranges from 3.5 to 4.5 m in elevation.

4) Flow Capacity of River

Through the hydraulic analysis, flow capacity is verified at 300m3/s in Guinea, 1,100 m3/s in Filadelfia and 1,700 m3/s in Palmira. Thus, it can be said that the flow capacity of the Tempisque river is the flood scale of 10 year probability on the upstream end and the flood scale of 3 year probability on the downstream and in the middle stream reach. The river section between the Palmas-Bolsón and Cañas-Charco rivers confirmed through the field reconnaissance is 50 to 100m2 at mid to downstream reaches and flow capacity of these rivers can be estimated at 100 to 300m3/sec.

5) Present Land Use

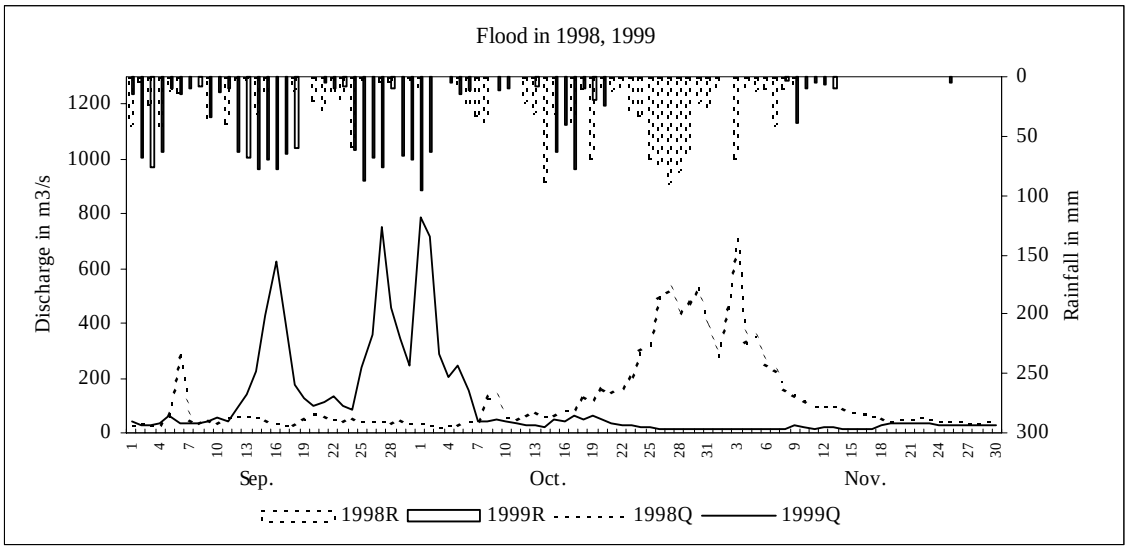
Presently, downstream areas of the Tempisque River Basin are utilized as farmlands except for the area of Palo Verde National Park. Originally, these farmlands are developed in the inundation area of the river and have high possibility of inundation damage. Farmlands without tidal influence are used for sugarcane cultivation including enterprise scale farming. Others are used as pasture, for tidal fluctuation and seasonal flood affect these farmlands. When farmlands are located near the riverbank, dyke is generally constructed with various scale and structures. These dykes prevent smooth evacuation of excess water caused by inundation.

(2) Actual Status of Damage

Damages of houses and farmlands are the major damage caused by inundation in the Study Area. Secondly, damage of basic infrastructure is counted such as roads, bridges, domestic water supply and sewerage facilities. During inundation, information of refuge, climate and so on are informed to the related local residents through the substructures of CNE such as CRE, CLE and CCE. Also, local residents take refuge voluntarily with the increasing of water level of the river. With these procedures, human damage by inundation has been found scarcely in the Study Area. At the time of hurricane Floyd in October 1999, 400 houses, 76 infrastructure facilities, and 16,000 ha of farmland were damaged. Most of the damaged houses were in Corralillo. Settlements located below the altitude of 10m above sea level and in Guinea along the Tempisque river. On the other hand, although being isolated by road flood, no damage was confirmed in the central part of Ortega and Bolsón located in the downstream area of Corralillo settlements, for their settlements were formed on higher areas over 10m above sea level.

(3) Hydrological Conditions at the Time of Hurricanes Mitch (1998) and Floyd (1999)

Among the floods recently occurred, the figure below shows the discharge records of Guardia station and rain fall records of Tempisque station for hurricanes Mitch (1998) and Floyd (1999).



Flood Conditions of hurricanes Mitch (1998) and Floyd (1999).

The total runoff volume at Guardia observatory during the rainy season in 1998 corresponds to 5 years exceedance probability as well as 10 years probability in 1999. (Peak discharge is not recorded in both years.) On the other hand, exceedance probability of areal rainfall corresponding to the runoff at Guardia observatory has the same probability as runoff on both years. However, observed rainfall at Tempisque weather station located in the downstream of Guardia station, corresponds to 100 years of exceedance probability. (Total rainfall from September to November counts around 1,800mm and 800mm in average years, respectively) With these hydrological conditions, it can be said that a flood with more magnitude than the aforesaid probability had occurred in the Tempisque main river course at the Palmas and Cañas rivers in 1999. Thus, the flood brought magnification and prolongation of inundation in the downstream reach of the basin and spread the limits of damage.

(4) Flood Countermeasures

To prevent and/or mitigate the inundation damage caused by flood in the Tempisque River Basin, numerous countermeasures are considered and taken by the related governmental organization and/or offices. Major countermeasures performed for floods are as follows:

- Construction of dyke at the left bank of Tempisque River from the north of Angels to Guinea.
- Construction of dyke (15km in length) at the right bank of Tempisque River from Guinea to the old Guabal lake.
- Construction of dyke at the right bank of Sardinal River.
- Construction of dyke (3km in length) at the right bank of Tempisque River near Filadelfia.
- River course improvement near Bolsón and Ortega.
- Short-cut works of river course at the downstream reach of Tempisque River.
- Dredging works of river course at the downstream reach of Tempisque River.

Furthermore, CRE considers various countermeasures for floods to be taken in the future. Those measures can be summarized as follows:

- Utilization of roads as dykes through piling works of existing road from Palo Blanco to Ingenio near Guinea at the right bank of Tempisque River.
- Dredging works of river course at Palmas-Bolsón Rivers up to the confluence with Tempisque River.
- To elevate drainage effects at town areas of Filadelfia and Bambu area, through construction of a drainage canal from the highland areas of Jocote to El Relleno Farm through Ojochal and Las Palmas Farms.

- Reexamination of the Tunnel Plan (A part of the flood occurred at Tempisque river will be enabled to evacuate to the gulf of Papagayo directly from Monte Galan through a tunnel.)
- Preparation of refuges for flood time (Ensuring utilization of existing building and/or construction of public halls.)

3.3 SOCIO-ECONOMIC CONDITIONS

3.3.1 Social Situation

In the Study Area and its surroundings, public services and social infrastructure are sufficiently provided by the government; health care, education, water supply, electric power supply and roads. With regard to the living standards of the dwellers, the line of poverty is overcome when it comes to income, housing, holdings and food intake, etc. Nevertheless, this does not mean that there are not any inhabitants with scarce economic resources. Indeed, agricultural workers or single-mother families do not acquire enough income to support their families. Thus this must be improved.

The current situation of the Study Area and its surroundings is described as follows:

(1) Rural Society in the Study Area

While independent and small-scale farmers planted coffee trees in the Central Valley, the Study Area and its surroundings were developed with large-scale ranch farmers and laborers hired by them as foundation. Consequently, only a few traditional and spontaneous villages arose.

The existing communities have different names such as *comunidad, localidad, sitio, barrio* and *caserio*. In these communities, *Parceleros* as a result of the settlement framework plan of the Agricultural Development Institute (Instituto de Desarrollo Agrario, IDA) are not traditional communities and have rather weak links between their members.

On the other hand, there are also small and medium producers, called "*finca*"that have traditionally lived in the area. According to the latest official records, in the previous years these *finca*s made up around fifty family households in the six districts of the Study Area.

Additionally, there are around fifteen large-scale farmers whose establishments are called *haciendas*. Even though there is no clear difference between *finca* and *hacienda*, in terms of area and production scale, *hacienda* seems to refer to the traditional, large-scale farmers of the region, and *finca*s may denote the small and medium lands owned by independent farmers. Yet, it is also common to label finca as every agricultural land. Historically, large-scale farmers have owned large extensions of land, some of which reached tens of thousands of hectares between Puntarenas and Nicoya. Presently, land of big producers (including enterprises) extends to hundreds or thousands of hectares.

Parcelas are sparsely distributed along the cantons of Carrillo, Santa Cruz and Liberia; on its surroundings numerous *parceleros* live. Some villages are well established with some elements of traditional settlements; for instance, in Sardinal, Filadelfia and the surrounding areas, one can perceive a human bond among the inhabitants, a bond that is settled upon a communal consciousness. Typically, most farmers do not favor living isolated from others. For this reason they would rather live in the nearby towns or villages. Accordingly, many producers do not live close, or even sometimes live considerably far from their *parcelas* (land).

Another characteristic feature of the area is the presence of agricultural workers, which plays a determined role for the agriculture of Guanacaste and which makes a part of the rural society of this province. For the production of sugar cane and melon, their presence is indispensable. However, these workers are only employed from around December to April; the rest of the year they toil in the Central Valley coffee plantations, or they just remain unemployed. Some of the population is conformed by Nicaraguan immigrants who came to the place searching or employment opportunities. Many of them are illegally living in the country and form the lowest level in the rural society, along with the single-mother families. Many of the Nicaraguans live temporally in the area during the melon harvest, and then around April, they move to the Central Valley to work there. Due to the high incidence of

immigrating and emigrating workers, the actual situation of this population segment remains unknown.

(2) Communities and Number of Families in the Study Area

The number of families have been estimated based on the information provided by EBAIS, the government population statistics of 1999, and the data collected during the on site survey.

Estimated Numbers of Families

Canton	Districts/Number of Communities		Population of Districts	Number of Families	Study Area	
					Communities	Number of Households
Liberia	Nacascolo	15	1,200	300 - 400	Only Guardia	150 - 200
Carrillo	Filadelfia	Urban	4,000	6,300	Partial	Partial
	Sardinal	Urban	4,000		Partial	Partial
	Filadelfia	30			All 4 districts	2,300 - 2,500
	Palmira	11				
	Sardinal	24			Partial	
	Belen	21				
St. Cruz	Bolsón	6	1,500		Ortega	250

(3) Colonization and *Parcelero*'s Society

Agriculture in Costa Rica was developed mainly around large-scale farmers. In the late 1950s, strong worldwide trends demanded agrarian reforms. Encouraged by such trends, agricultural workers started to squat banana plantations and pasture areas. To face this situation, and in an attempt to grant land to those who did not own any, the government decreed the Organization Law (Law No.2825) in 1961, and then in 1962 established the Institution for Land and Colonization (Instituto de Tierra y Colonización, ITCO). The institution, which started functioning in October 1993, was in charge of expropriation. Afterward, in 1982 this institution was restructured as the present Agrarian Development Institute (IDA). As result, colonization policies overtook the agrarian reform.

IDA purchases land from the large-scale farmers, and then, after a meticulous examination of each petitioner, IDA sells the land to the chosen petitioner under certain conditions such as restricting the purpose of the land. Normally, the payment is completed within a 15 to 25-year period and then when it is finally completed, the adjudicator is entitled to the ownership of the land. *Parceleros* are those farmers who are processing the acquirement of the land title, and a *parcela* is the sold land to the adjudicated farmer. In the Study Area, there are around 12 settlements with more than 400 adjudicated families (*parceleros*). Few of them are living in the settlement; many are still residing in the urban areas and commute to the land for work. The average size of a *parcela* is 7.4 ha. Most of them do not have irrigation facilities and is used for the seasonal sowing of rice or sugar cane using rainwater. Despite the fact that *parcelas* are grouped in determined geographic zones, their owners frequently live far away, and sometimes even in other cantons or in San Jose.

(4) Farmers' Organizations

Though the farmers in the Study Area are very well organized, not all of the organizations are in good function.

Category of Organization	Number of Organizations	Category of Organization	Number of Organizations
Development Associations (Asociacion Desarrollo)	9	Cooperatives (Coope)	9
Women's Associations (Asociacion de Mujeres)	7	Producer's Associations (Asociacion de Productores)	2
Village Associations (Asociacion)	2	Associations of *Parceleros* (Asociacion de Parceleros)	2
Cooperatives of *Parceleros* (Parceleros de Coope)	1	*Parceleros* (Parceleros)	2
Small Farmer's Associations (Asociacion de Pequenos Agricultores)	2	Agricultural Producer's Associations (Asociacion de Agricultores)	2
Producers and Service industry Associations (Asociacion de Productores y Servicios)	1	Small Producer's Associations (Asociacion de Pequenos Productores)	1
Hog Raiser's Associations (Asociacion de Porcicultores)	1	Handicraft Associations (Asociacion de Artesanales)	1
Stock Farmers' Association (Asociacion de Ganaderos)	1	Horticultural Producer's Associations (Asociacion de Horticultores)	1
Pepper Producer's Associations (Asociacion de Productores de Chile)	1	Groups of Finca (Grupo Finca)	1
Women's Groups (Grupo de Mujeres)	1	Associations of Orchards Women (Asociacion de Mujeres de Pulpa de Fruta)	1
Chambers of Sugar Cane Producers (Camara de Productores de Canas)	1	Chambers of Stock Farmers (Camara de Ganaderos)	1
Groups of Neighbors (Grupo de Veninos)	1	Societies of Neighbors (Junta de Vecinos)	1
Associations of Environmental Conservation (Asociacion Conservacionista)	2		

According to survey results, 14 out of the 57 organizations mentioned above are neighbor's associations, community groups or environmental organizations. One third of the 43 farming or farmer's organizations have closed down their activities and exist just by name, and many of them are not adequately active.

The Study Team conducted detailed survey on 25 organizations, consisting of five cooperatives, fourteen associations, four communal banks, one chamber and one group.

1) Cooperatives

Cooperatives are usually formed on the basis of joint production and social welfare. Their history is fairly long, some beginning from the 1960's. Cooperatives embrace a considerably high number of associates and practice common employment and common ownership of land. Nevertheless, due to the difficulty of management, there are no cooperatives recently formed.

For the five studied cooperatives, the maximums were; 360 hectares of commonly owned land and 44 associates, while the minimums were 68 hectares (the corresponding cooperative used to own 143 hectares but sold the portion for financial difficulty) and 25 associates. Four of the cooperatives own irrigated lands and one of the cooperatives closed their agricultural activities as they switched over to environmental conservation and education.

2) Associations

Associations are the most predominant of the community organizations in the area, and is the form of organization encouraged by NGOs and governmental agencies such as IDA, PRODAPEN and MAG. The registration procedures are relatively simple. With twelve associates signing over an agreement as they settle their leader, the association can be registered through necessary legal procedures. Though an association has an obligation of annual activity reports and annual election of it's officials, there are no further restrictions. In the asentamientos (an aggregate of parselas), IDA compelled the formation

of associations of farmers desiring land as a prerequisite. Therefore, after the acquisition of land, associates resignation and collapse of associations due to deceleration of activity occurred in these associations.

Three of the abovementioned associations own land partly irrigated, two of them are in dormancy. One of the associations resides in the Study Area but owns land outside of the Study Area.

3) Communal Banks

Communal Banks are a kind of association of mutual financing for those who cannot receive bank accommodation. Some of these communal banks also involve agriculture. The communal bank consists of farmers who do not have access to credits, or those planning initiation of small enterprises. The source of revenue is maintained by selling stocks called accións or credits to the associates, or by receiving a loan from banks as an organization and then operating the loan with 2-3% addition. In addition, communal banks possess juridical personality.

Besides the abovementioned, four communal banks went into dormancy.

Even though each one of the twenty-five organizations face serious administrative difficulties, eight of them were identified as solid enough to be able to keep on, three of them broke apart, and fourteen might still keep on if they could obtain some sort of support.

The greatest difficulty for the collapsed organizations as well as for those suspended or fairly surviving is the progressive withdrawing of their members, due to the advantages or incentives of being an associate are not being clear; as a result, the vitality of the organization starts to fade until it is necessary to cease their functioning.

The second, important reason refers to the disagreements on budget management. In some cases, the member's contribution or any given fund were poorly handled or stolen; this holds back member's motivation in relation to the organization activities.

The third case is the deficiency of resources to carry out their activities due to inaccessibility to bank credits and failure in collecting money from the farmers. This results also in the lack of interest toward the organization's activities.

These are the main trends that the surveyed organizations presented. Yet, it may be possible for these organizations to keep on working if they are granted the support either from public institutions or from NGOs. The members of these organizations are or have been receiving some kind of support; although, in some cases the instruction and techniques that were taught have not been applied practically. It is believed that if the different methods of support are adjusted to the local reality, they could potentate the farmers.

Following is the chart showing the results of the survey on the 25 organizations.

Record of Hearing from the Existing Organizations in the Study Area	
1. Asociación de Horticultores de San Blas, San Blas, Sardinal, Carrillo	
a. Date of establishment:	1999, registered in 2000
b. Number of members:	11 (5 men and 6 women), **farmers: 11**
c. Activities:	Peppers, melon and watermelon production
d. Assistance by:	SENARA, PRODAPEN, MAG, FAO
e. Status:	They have a good and ambitious leader, but their market is not very stable.
2. Coope Rio Palmas, R.L., Los Palmas, Belen, Carrillo	
a. Date of establishment:	1982
b. Number of members:	28 (15 men and 13 women), **farmers: 18**
c. Activities:	Rice and sugar cane production
d. Assistance by:	MAG, PRODAPEN
e. Status:	They have a long history, but they have a major administrative problem, along with mischievous behavior of members.
3. **Empresarios Copa,** Paso Tempisque & Comunidad, Palmira, Carrillo	
a. Date of establishment:	1999 (in the process of registration and organizing)
b. Number of members:	10 (1 man and 9 women), **farmers: 1**
c. Activities:	Trying to set up a restaurant and a fruit process plant
d. Assistance by:	PRODAPEN, MAG, INA
e. Status:	They are unstable due to their recent organization process and need more assistance.
4. **Asociación de Arenas Artesanales de Valle del Tempisque,** Filadelfia, Carrillo	
a. Date of establishment:	Registered in 1999
b. Number of members:	120 (100 men and 20 women) + 50 (carters) + 20 (shippers) **farmers: 20**
c. Activities:	Gravel extraction, reforestation, tourism
d. Assistance by:	MAG, MINAE
e. Status:	Stable and solid, planning to expand their activities
5. **Banbesa Bancomunal de Belén,** Belén, Carrillo (Banco Comunal)	
a. Date of establishment:	1997
b. Number of members:	22 (18 men and 4 women), **farmers: 14**
c. Activities:	Providing loans to the members, planning to set up a small business (bakery, garments, etc.)
d. Assistance by:	INA, IDA, MAG
e. Status:	Goals and activities defined, but they more training.
6. **Asociación Hortícola de San Miguel,** San Miguel, Filadelfia, Carrillo	
a. Date of establishment:	1994, registered in 2000
b. Number of members:	15 (9 men and 6 women), **farmers: 13**
c. Activities:	Peppers, watermelon, and melon production. Planning to grow onions.
d. Assistance by:	SENARA, MINAE, MAG, INA, IDA
e. Status:	Large amount of debts. Need land and accounting skills.
7. **Asociación Cámara de Productores de Cañas de Guanacaste**, Filadelfia, Carrillo	
a. Date of establishment:	1980
b. Number of members:	688 (small-scale farmers)
c. Activities:	Large purchase of agrochemicals
d. Assistance by:	DIECA, LAICA, FERTICA
e. Status:	Very solid and well assisted
8. **Grupo de Mujeres de Corralillo,** Corralillo, Filadelfia, Carrillo	
a. Date of establishment:	Not registered yet.
b. Number of members:	11 (3 men and 8 women), **farmers: 2**
c. Activities:	Currently, the group is almost inactive but planning to raise chickens, grow frijoles and food processing.
d. Assistance by:	PRODAPEN, MAG, IDA
e. Status:	Unstable and financially weak. Focused projects and willingness to work.
9. **Asociación de Agricultores de Corralillo,** Corralillo, Feladelfia, Carrillo	
a. Date of establishment:	1988, registered in 1991
b. Number of members:	8 (8 men), **farmers: 8**
c. Activities:	Sugar cane production
d. Assistance by:	EPRODES
e. Status:	Accountancy not solid and high level of debts

Record of Hearing from the Existing Organizations in the Study Area	
10. **Bancasti,** (Banco Comunal Castilla de Oro)	
a. Date of establishment:	1990, registered in 1999
b. Number of members:	14 (6 men and 8 women), **farmers: 14**
c. Activities:	Corn production, cattle raising, inhabitant welfare and cultural activities, lending money to members
d. Assistance by:	FINCA, PRODAPEN
e. Status:	Not only production activities, but also cultural ones. In need of accountancy training.
11**. Asociación de Productores Agroindustriales,** Corralillo, Filadelfia, Carrillo	
a. Date of establishment:	2000, registered in 2001
b. Number of members:	10 (6 men and 4 women), **farmers: 10**
c. Activities:	Frijoles, yuca and vegetable production. Planning to set up a small-scale chicken processing plant, and to produce sugar cane and corn
d. Assistance by:	MAG, IDA, INA, PRODAPEN
e. Status:	Group of young people. Assistance provided, but skills not applied practically. Planning diversification.
12. **Asociación Agrícola Campesina de Río Cañas,** Río Cañas, Belén, Carrillo	
a. Date of establishment:	Registered in January, 1994
b. Number of members:	10 (1 man and 9 women), **farmers: 10**
c. Activities:	Rice, corn, and vegetables production
d. Assistance by:	MAG, IDA, Vision Mundial
e. Status:	Good functioning. Available land is only 7,5 ha. Debts and lack of water.
13. **Banco Comunal de Corrallilo Filadelfia,** Corrallilo, Filadelfia, Carrillo	
a. Date of establishment:	November, 1998
b. Number of members:	11 (7 men and 4 women), **farmers: 7**
c. Activities:	Financing their members.
d. Assistance by:	PRODAPEN
e. Status:	Their purpose is to finance the members, but due to the lack of funds the organization is fairly working.
14. **Cooperativa Agrogestionario de Carrillo, Coope Carrillo**, Filadelfia, Carrillo	
a. Date of establishment:	1985
b. Number of members:	17 (17 men), **farmers: 17**
c. Activities:	Irrigated production of sugar cane and vegetables.
d. Assistance by:	MAG, CNP
e. Status:	Enough experience, but not very active. A major part of their land is let untilled. Highly dependable on assistance and support.
15. **Asociación de Agricultores y Servicios Las Palmas,** Sardinal, Carrillo	
a. Date of establishment:	1995, Registered in 1997
b. Number of members:	41 (20 men and 21 women), **farmers: 12**
c. Activities:	Basically, attempting to improve public services. Practicing organic agriculture as an employment opportunity for women.
d. Assistance by:	IDA, ASA, PRODAPEN, Vision Mundial
e. Status:	Great efforts for improving the well being of their fellow citizens. Creating job opportunities for single mothers. The production of organic crops is relatively stable. They have a market.
16. **Cooperativa Agropecuario Industrial, Coope Sardinal, R.L**., Sardinal, Carrillo	
a. Date of establishment:	1976
b. Number of members:	25 (20 men and 5 women), **farmers: 25**
c. Activities:	Basically, mutual help among the members. Rice, corn and sorghum production.
d. Assistance by:	CONACOOP, LD
e. Status:	They have a long history and are attempting to carry on with the cooperative, but they are losing vitality. Their land resources are somehow being wasted. Willing to set up an irrigation system.
17. **Cooperativa Agropecuaria de Servicio Múltiples, Coope Río Cañas,** Río Cañas Nuevo, Belén, Carrillo	
a. Date of establishment:	1960, registered in 1968
b. Number of members:	44 (39 men and 5 women), **farmers: 44**
c. Activities:	Mutual help among members. To improve their members' living conditions.
d. Assistance by:	MAG, INFOCOOP
e. Status:	Production of sugarcane, corn, rice, melon and watermelon. Due to the instability of the market, their access to credits is limited.

Record of Hearing from the Existing Organizations in the Study Area	
18. Asociación de Pequeños Agricultores Río Cañas, Río Cañas, Santa Cruz (Asentamiento de Piragua)	
a. Date of establishment:	1993, registered in 1995
b. Number of members:	13 (11 men and 2 women) **farmers: 13**
c. Activities:	Rice, pirpián, sugar cane, corn production and vegetable production for hotels
d. Assistance by:	IDA, MAG, IMAS, PRODAPEN
e. Status:	Used to be solid. Presently, weak and with financial difficulties.
19. **Asociación de Filadelfinos**, Filadelfia, Carrillo (Asentamiento La Piragua)	
a. Date of establishment:	Registered in 1999 (currently broken apart)
b. Number of members:	11 (when functioning)
c. Activities:	Sugar cane and rice production in common lands.
d. Assistance by:	MAG
e. Status:	After its foundations, it gradually disorganized for no particular reason. Currently production is by individuals
20. **Asociación para el Desarrollo de la Cuenca Baja del Río Tempisque RAICES,** Ortega, Santa Cruz	
a. Date of establishment:	1993, registered in 1994
b. Number of members:	34 (23 men and 11 women) **farmers: 17**
c. Activities:	Environmental monitoring and education. Organic agriculture.
d. Assistance by:	UNA, UNDP, AFS, DUCKS
e. Status:	Basically, an environmental organization. Also dealing with organic agriculture. In a growing process.
21. **Cooperativa Autogestionaria de Ortega, Coope Ortega, R.L.,** Ortega, Santa Cruz	
a. Date of establishment:	1984, registered in 1985
b. Number of members:	18 (12 men and 6 women) **farmers: 5**
c. Activities:	Reforestation, tourism, organic agriculture, environmental education and chicken processing.
d. Assistance by:	Banco Cooperative, NGO of Belgium
e. Status:	Very stable organization. Against the present manner of agriculture and encourages organic agriculture. Currently, their activities are suspended.
22. **APAO-Asociación Pequeños Agricultores de Ortega**, Ortega, Bolsón, Santa Cruz	
a. Date of establishment:	1983
b. Number of members:	23 (13 men and 10 women) **farmers: 23**
c. Activities:	Producing sugar cane, lemon, mango, etc. as well as cattle raising and sowing pasture.
d. Assistance by:	MAG, CNP, FUNDE, INA, PRODAPEN
e. Status:	A good leader. Fairly stable. Their market is unstable.
23. **Asociación Agricultores de Río Tempisque**, Filadelfia, Carrillo	
a. Date of establishment:	1990-1999 (collapsed)
b. Number of members:	25 (25 men) **farmers: 25 (when functioning)**
c. Activities:	Used to grow tomato, corn, rice, pipian, and melon for export.
d. Assistance by:	Monsanto,CINDE, IDA
e. Status:	Deprived of their title for many of the associates were not suitable to IDA standards and consequently collapsed.
24. **AsoAgriCo-Asociación de Agricultores Orgánicos de Castilla de Oro**, Castilla de Oro, Filadelfia, Carrillo	
a. Date of establishment:	1996, registered: 1999
b. Number of members:	6 (3 men and 3 women) **farmers: 6**
c. Activities:	Production of tomato, peppers, cilantro, and beans. (direct market links with hotels and supermarkets).
d. Assistance by:	INA, TEC, MAG, CNP
e. Status:	A forerunner organization in organic agriculture with greenhouse.
25**. Bancomunal de Sardinal**, Sardinal, Carrillo	
a. Date of establishment:	1997—2000 (suspended)
b. Number of members:	33 (29 men and 4 women) **farmers: 33 (when functioning)**
c. Activities:	Corn, pasture, and seeds production as well as pig raising and credits
d. Assistance by:	AGUADEFOR, FINCA
e. Status:	Lack of member's interest broke down the organization.

(5) Survey on Farm Households

Following are the results of the survey on irrigation construction areas of the Phases 1 and 2 of the Arenal-Tempisque Project:

1) Sample size

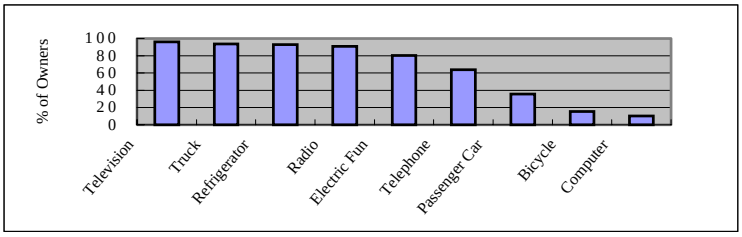
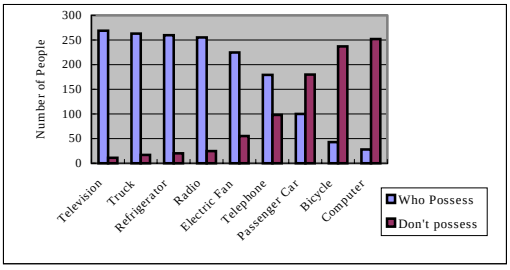
The samples sum up to 400, considering a reliability level of 90%.

Areas	Type	Sample Numbers
Study Area	Small/Medium-scale Farmers	288 Households
	Large-scale Farmers	13 Households (covering all large-scale farms)
Areas of Phases 1 and 2	Small/Medium-scale Farmers	100 Households

The results of the survey are summarized in the following chart:

Small and Medium-Scale Farm Households		
Family omposition	Average No. of Family Members	4.19 Persons (Guanacaste Average: 4.09, Costa Rica Average: 4.08)
	By Age	Under 11 years old (Under elementary school): 14.5% 12 ~ 39 years old: 44.2% Over 40 years old: 41.2%
	By Sex	Men: 55% Women:45%
Education	There are 19 Elementary schools in the Study Area, distributed to almost every village. However, the students have to commute to towns or larger cities for secondary schools. Nineteen elementary schools in the target area.	
	Rate of illiteracy: 0.5%	
	Completion Rate of Elementary School (over 12 years old)	Completed: Women 17.4% Men 23% Not Completed: Women 28% Men 32%
	Graduation Rate of Secondary School	Graduated: Women 4.2% Men 8.8% Not Graduated: Women 16.5% Men 21%
Income/ Occupation	**Occupation**	Total Number of Households: 288 Agriculture: 276, Agriculture With Livestock Farming: 25 Most people have second jobs.
	Economically Active Population	700 ~ 800 persons excluding pensioners (excluding farmers, housewives, students and people not applicable, some 200 people had occupations)
	Major Occupations	Teachers 27 Home Helpers 10 Merchants 27 Administrators/ Engineers/Mechanics 22 Clerks 9 Operators 10 Secretaries 7 Laborers 10 Drivers 7
	Average Incomes	Per Person/Month ¢100,000 (Per Household: ¢170,000) Minimum/monthly: ¢3,500 (pensioner) Maximum/monthly: ¢750,000 (engineer)
Incomes of the 40% of the lowest income groups average 60,000 colons per person, which is lower than the minimum salary (77,000 colons) set by the Labor Law. Similarly, the incomes of the 40% of the lowest income group families is less than 80,000 colons. On the contrary, the income per person of the richest 10% is over 200,000 colons, and the income per household of the above is over 400,000 colons. It should be noted that the average income in the Target Area is higher than the national average of 1999, which is about 162,000 colons. However, this is the result of small numbers of extremely high-income groups pushing up the average of the low-income groups. Further, 86% of the households responded that the incomes during the past five years have decreased or have not changed. Only 13.5% of the farmers indicated that their incomes have increased. According to the national economic indicators of recent years, Costa Rica has favorable economic situations. It seems that the good economy of the national level does not fully trickledown to the level of farmers.		
Social Infrastructures/ Social Services	**Medical Services/ Healthcare**	Medical services and healthcare in Costa Rica are built upon the system of Health Divisions, and Teams for Integrated Primary Healthcare (EBAIS), that provides healthcare for each division. Chorotega Region is divided into 12 Health Divisions, and 8 EBAIS are located in Liberia Canton, 5 in Carrillo, and 9 in Santa Cruz Canton. Further, Health Posts are situated in some remote villages, and district general hospitals of higher level are located in cities, for example, in Liberia. 87% of the studied population is covered by Costa Rican Social Security (Caja Costarricense de Seguro Social), and 77% of the households answered that they generally use a clinic of the above social security or EBAIS when someone gets sick.

Small and Medium-Scale Farm Households

	Water Supply	The construction of social infrastructure in Costa Rica is well extended to rural areas. There are only a very few houses without water supply systems. Of 281 households (7 answers were not valid), 92% of the households had water supply by pipelines into or outside of the house. Only 8% of the households have to use either well or river water. Even so, the water sources are available within 50 meters of distance.
	Electricity, Communication, Information	Of 280 of households (8 were not valid), 269 households, which had approximately 96%, are provided with electric power. There are some households using electricity for cooking, in addition to lighting. Many other families use propane or woods for cooking because charges for electricity are expensive. The diffusion of telephone is not wide spread as electricity. Only 179 households, about 64%, possess telephones. The most widely prevailing source of information is the television. Nearly all households that are provided with electric power possess television. Fore other sources of communication or information, there is the radio with the diffusion of 91%, and a small share of computers with the diffusion of 10% (28 households).
	Road and Transportation	The roads of the Study Area are generally well maintained. Some of the roads are not paved, but roads in very bad conditions are scares. Nevertheless, many roads are cut off during the rainy seasons when the areas are flooded and become impassable. For public transportation, various regular public bus services are available in and around the Study Area connecting the villages. However, frequencies of the bus services are limited, or in cases buses do not reach the villages. Thus, although bus services are available, it is not sufficiently covering all the villagers in need.
Housing/ Property Possession	As previously mentioned, the majority of surveyed farmers live in villages and cities nearby or sometimes (about 5%) considerably far from their farmlands. Few of the families live in their farmlands.	
	Housing Of the surveyed households, 95% own houses. Out of the 95%, five percent of the households are still paying their loan. The other 5% live in rented houses. An average monthly rent is about 22,000 colones. The building materials used for the houses are as follows: Outer walls: 60% Cement blocks; 25% Woods; 15% Mixed materials and pre-fabricated. Roof: 100% (almost) Zinc; 3 houses out of 280 Slates. Floor: Cement, mortar, wood, tiles, and earth	
	Owned Property Nine items were selected to measure the property owned by the farm households. These are;television, truck, refrigerator, radio, fan, telephone, passenger car, and computer.	
	Property Owned (Percentage of Households)  Comparison with those who have and have not (Actual Numbers)  	
	As shown above, most of the households own television, and the majority of the households, 94%, also own a truck (Only 17 households do not own a truck). A refrigerator is used by 93%, and a passenger car is owned by 36% of the surveyed households (100 households).	

Small and Medium-Scale Farm Households

Food In take

Staple foods are; a combination of rice and frijoles, bread, and corn. Side dishes are vegetables, fruits, eggs, milk, cheese, sausages, beef, pork, chicken and fish. As a staple food, the combination of rice and frijoles, called "gallo pinto" is the most favored food, eaten by 97% of the people every day, followed by bread, which intake is about 72%. Corn as the staple food is eaten by about 60% of the people. Seventy-four percent of the people eat fruits every day, and 60% eat vegetables at the same frequency. If added those who take fruits and vegetables a few times per week, some 90% of the studied households frequently take fruits and vegetables. For the protein intake, which is important for favorable growth of children, eggs are most widely eaten. Intakes of other protein sources such as various meats are also fairly high.

Gender

Of the surveyed people, about 86% admitted those opportunities are not equal. On the decision making power in the household, 53% answered that the decisions are made by men on farm activities. On the other hand, 36.5% say that the decision on what to buy is left to women. Nevertheless, the decision on handling of money rests on men in many households. About 30 to 50% of the people say that other decisions are mutually made between husband and wife. Further, 61% women do not own the land under their name, and 63% responded that they do not have an independent bank account with their own name.

Recognition On Environment

Eighty-Two percent of the sample households answered that the surrounding environment is ether not improving or said deteriorating. According to the responses, one of the major sources of environmental degradation is by the burning of sugarcane. First, the burning causes air pollution with smokes, dust, and soot. Also, air temperature goes up. Some 23% of the people consider water pollution of the rivers is the most urgent environmental problem. Other 21% responded that the problem is deforestation. On the contrary, only 3% think floods are the problem, and 1% feels that drought is the problem. Many of the farmers surveyed, 77%, responded that they are attempting to use some measures to improve or not to damage their environment by applying a so-called "a farming that is gentle to environment." Some of such attempts are, for example, the use of the plague-resistant seeds, inorder to reduce the use of agrochemicals as much as
possible, remove after-harvest residues and weeds to avoid pollution and diseases, or practice crop rotation. Also, 18% of the farmers use organic fertilizers, and other 16% use biological insecticides for pest control. From the above practices, it can be said that the farmers in the Study Area have considerable degree of interest and pay attention towards the environment. It should be understood that the air pollution brought up by the farmers is extensive and severe due to the fact that the Study Area is one of the major production areas of sugarcane, and that the harvest time coincides with the dry season of the region when the air is completely dry, the dust and residues of the burnt sugarcanes and soot fly around, and is scattered by the strong winds that blow daily during the dry seasons.

Flood Damages

Approximately 60% of the households answered they have received damages by floods. Of those, about half of the people say that they are repeatedly damaged. The families who have never experienced damages by floods were 40%.
Extent of damages:

	Partial Damage (%)	Total Damage (%)
Overall	35%	14.2%
Houses	25%	2.4%
Farm Infrastructure	21.2%	5.6%

Analysis of the Results of Socio-economic Aspects

Households/ Population in Study Area

-The households in The Study Area are of relatively similar composition, and the population is young
-The incomes are higher than it had been considered before, and the sources of incomes are diverse
-Although years of school attendance are short, the rate of illiteracy is very low
-Traditional villages exist more comparing to the Irrigation Areas Phases 1 and 2
-Social infrastructure and public services are fairly well extended
-In view of properties possessed and food intake, the area is not necessarily a "poor area" (as generally considered)

Problem Points/ Restraints

-Although literacy rates are high, the farmers lack of sufficient knowledge and skills of production
-Many organizations exist, but they are not necessarily operating in efficient ways.
-The majority of farmers live outside of the farmlands in nearby villages or in cities, or sometimes considerably far from their land. This fact may become an obstacle for forming organizations.
-Although many farmers maintain varied sources of incomes, there are very few opportunities for employment other than the harvest of melon and sugarcane. No other notable industries exist in the area, and thus, to sustain stable sources of income is difficult.

As explained above, the social services in the Target Area is sufficiently maintained, and the people are not particularly in the condition of "poverty" considering the living conditions of the households, the property possession, or food intake. One particular point that has to be mentioned is the fact that many farmers seem to have been separated from soil, that is, they are not anymore the traditional farmers who till their land. No other major social problems are seen in the Target Area.

Large-Scale Farmers (Enterprises) –

For all large-scale farmers in the Study Area are enterprises, the study was made focused on these farmers as providers of employment opportunities

Target **Crops**	Out of 13 enterprises, only the melon producers and one of the nursery industry are relient to the production of a single crop. All other enterprises produce two to three different kinds of products or practice livestock farming along with crop production. The main forms of production are sugarcane, livestock, rice, melon, fodder, mango, Jalapeno pepper, and nurseries. These are the principle crops as well as the secondary and tertiary crops sometimes.
Employment	Of the above-mentioned large-scale farmers, only two are large industries. These enterprises employ approximately 1,250 laborers at their peak time (for sugarcane and melon harvest). For other enterprises, there are, two enterprises with 600-650 people, one with 300, two with 20 and 7 generally with 1-8 laborers. Small firms employ only local people, but large firms sometimes employ foreigners, mainly Nicaraguans. No exact statistics are available, but it is estimated that some 25% of the entire labor force are of foreign origins at the peak time.

Irrigation/Construction Areas of Phases 1 and 2-

Progress of Land Acquisition	The Irrigation Construction areas of Phase 1 and 2 were created through purchasing the land of large-scale farmlands that had been underutilized. The IDA purchased the lands, and SENARA constructed irrigation facilities. Then, upon appraisal of the applicants, the IDA distributed the parcelas to the appropriate applicants. Thus, some of the villages and societies have been artificially created for the newly settled people.
General Conditions	Majorities of the new settlers (about 69%), practice monoculture of rice production. Some 13%, produce sugarcane and others practice livestock farms and vegetable production. Because almost all the lands are irrigated, credits from banks are relatively easily available. But, farmers generally don't work on rice production as they produce rice by contract. Therefore, a number of farmers have other occupation, and their income per person is relatively high. However, various problems as indicated below can be seen:
Problem Points	- As explained above, some villages have been artificially created, or many people live in larger cities, such as Bagaces and Canas or in new villages. Accordingly, organizations cannot actively operate because the sense of togetherness among the people or human bondage is weak. - The farmers are unable to understand the problems arising in their lands because as stated, they do not live in or live around their farmland. - Some of the new villages are without public services, that is, without bus services, and are becoming isolated. - For credits are easily obtained, it sometime results in stagnation of repayment and pressured household economy. - Though many landless people became landowners, they do not till their obtained land and rely on employed labor.

3.3.2 Regional Economy

(1) General

The Chorotega Region, i.e. Province of Guanacaste, consists of some layers of mosaic work. The base is formed by a mixture of micro geo-morphology with micrometeorology, which leads to biodiversity, culminated into the top strata of human socio-economic activities. The present boundary is divided into 7 divisions geo-morphologically as shown below.

I. Guanacaste Volcanic Ridges including the south-western slopes
II. Santa Rosa Tableland
III. A part of (I)'s north-eastern slopes (excluding the southern coasts of Lake Nicaragua)
IV. Nicoya Complex
V. Tempisque & Bebedero Valleys
VI. Tilarán Ridges, including the north-eastern and south-western slopes
VII. Arenal Depression

Recently, after the waters from the rain on the slopes of the Caribbean side are transferred over the ridges, some communities of area V have been benefited. Therefore, area V is categorized into the

rain-fed agriculture sub-area and the new and old irrigation network sub-area.

In addition, according to the types of production activity, 10 areas could be classified in the rural region.

(A) Agro-industry mostly based on cultivation of rice paddy, melon, and sugarcane; Most of the activities are found in area V; (hereafter, will be indicated in numbers)

(B) Livestock and its industry; (a) Beef production (all areas), (b) Diary farming (upper part of VI),

(C) Small-scale mixed farming; (a) hilly area of IV, (b) II, (c) VI,

(D) Forestry; (a) Lumbering (all areas), (b) Orchards; i.Citrus* (all areas), ii. Coffee (IV, VI), iii. Mango (IV, V)

* Citrus production largely contributes to the agro-production of Guanacaste.

(E) Fishery; (a) Family practiced fishing (along the coasts of II, IV, VI), (b) Fish cultivation (V, VI)

(F) Salt pan industry; (along the shores of IV, VI)

(G) Energy production; (I)

(H) Mining; (VI)

Afterwards, two areas of activity were added.

(I) Activity of human being with increase of energy use as well as density has reached such a level that people have started noticing the need of conserving nature. Therefore,

(J) Conservation areas, called “AC”, were founded (AC Guanacaste, AC Arenal-Tempisque and AC Tempisque).

(K) At the same time, as peace prevails in the world, and productivity has increased Therefore,

(L) Tourist industry has started flourishing. [Coasts of IV, VII, around the entrances of “AC” and the international airport located in the enclave area of I.

Behind these activities are various supporters of economic development of The Region as the followings.

- So-called indigenous population; mainly the Chorotegas, who had migrated and lived here before the Spanish conquest.
- People having Nicaraguan ancestors; settled in this region before the foundation of Costa Rica.
- So-called “Cartago People”; who settled in this region in the early 20th century from the central valley, due to population pressure, natural disasters such as an earthquakes in 1841, 1910, and 1926, or periodic world recession. Many them mixed their race with indigenous people.
- The recent foreign immigrants; mostly destitute Nicaraguans with some other foreign entrepreneurs (including corporation) who have been contributing to productivity improvement of various economic activities.
- Government; Central government has strongly promoted an economic built-up program up to now. However local governments are developing their management ability in their area under the decentralization programs.

The main stay of the economy of the region has been agriculture. Recently, tourism industry has been developing rapidly. Therefore, general conditions of both industries are given below.

(2) Agriculture and Livestock Industry

In 1999, the farmed area of Guanacaste Province covered 17.5 % of the total farmed area in Costa Rica. The province also held 13.9 % of beef production and 3.8 % of milk production. The agricultural production has seen the vicissitude in the history. Beef cattle production was influenced by ups and

down of demand-supply, millet production was lost in international competition, production of cotton and beef were decreased or lost by market contraction and cacao was damaged by pest insects.

Considering the characteristics of the Study Area and this project, sugarcane, rice-paddy, melon, watermelon, pineapple, and fresh-water fish farming will be the focused products produced under the irrigation system. Under rain-fed agriculture condition, cattle breeding, production of mango are focused, with a possibility of joining cotton, which is a crop being invested continuously as raw material for textile & garment industry aimed at the opening of the US market. Chorotega region was one of the productive centers of cotton as much as millet in the 70s. These principal facilities were founded by ALCORSA, which was one of the 3 subsidiary companies, which were established as statutory companies of CODESA, in the Chorotega region. ALCORSA was defected in the market and no longer exists. There is only one Seedling Company considering the industry. The other 2 subsidiary companies; the CATSA, a sugar manufacturing company, and the CEMPA a cement manufacturing company, are in good operation.

(3) Tourist Business

The number of foreign tourists visiting Guanacaste Provinces in 1999 was approximately 400,000 persons. The total of foreign tourists visiting Costa Rica in same year were 1,000,000 persons, showing an average increase rate of 5.6 % since 1993. Guanacaste Province has three tourism areas in their tourist program, the corridor of Guanacaste north, the corridor of Guanacaste south, and the volcanic belt of Guanacaste. The first two correspond to the coastlines of Nicoya Peninsula and it is divided north and south by Junquillal point. The Northern division has been developed much earlier than that of the South. In 1999, the total of 5,000 hotel rooms existed in the province. 3,700 hotel rooms were in the Northern division (13 % of the country total), whereas 900 in the south (3 % of the country total). Presently, the Southern division is progressively developing. Two standards for the facilities are set for hotel registration. 60 % of these hotel rooms have cleared the requirement for the higher standard. Average rate of room occupation is estimated at 50 % for the hotels of higher standard and 40 % for the lower.

Tourism in Nicoya Peninsula, at a glance, may be considered to have potential as a favorable market for some agricultural crops in the Study Area. But further detailed study reveals the difficulty of even a single crop from the Study Area entering the market.

The PRODAPEN, which is a plan aimed at the small-scale farmers in the hills of Nicoya Peninsula, has been attempting to enter the market through horticultural production. On the other hand, tourist industries along the coast and agriculture industries in the midstream basin of the Tempisque River are in the relation of potential competitants on the utilization of ground water of the valley across the Nicoya Complex.

3.4 AGRICULTURE

3.4.1 Land Use

In the Study Area, the Tempisque River crosses the central part from North to South. On the left bank, one can find CATSA's sugarcane plantation, rice and melon fields, and large-scale pastures belonging to cattle raising families. On the right bank, settlements such as San Blas, Filadelfia and Belén can be found, where small and medium-scale farmers work on rice, sugarcane and melons along the flat areas near the river. On the higher sections, near the hills, the pasture areas prevail and so do corn, beans, watermelon and chili production areas in small, family-owned lands.

Along the Palmas River, there are numerous wetlands. Forests and swamps are sparsely distributed and unexploited, with an extension of 2,560 ha which make up approximately 7% of the total area (35,000 ha). The land destined to agriculture in the Study Area occupies 30,400 ha; which is composed by 10,600 ha for pasture, 19,500 ha for agricultural crops and 230 ha for fruit trees. The prevailing crop is sugarcane, rice and melons as well as other crops such as corn, beans, watermelon, and chili. Regarding fruit trees, mango prevails. In addition, shrimps are cultivated in the fishpond. The land use is summarized as follow:

Land use in the Study Area

Land use and Crops	Right bank of Tempisque River (ha)	Left bank of Tempisque River (ha)	Total (ha)	Notes
Agricultural Land	20,000	10,400	30,400	
- Rangeland	9.275	1,360	10,635	
- Sugarcane	5,950	6,150	12,100	
- Rice	3,000	2,370	5,370	
- Melon	1,230	400	1,630	
- Mango	110	120	230	
- Vegetables	155		155	Watermelon, Chili
- Others	280	-	280	Corn, Beans
Urban Area, housing	1,100	100	1,200	
Roads, riverbed	620	220	840	
Swamp, Forest, others	1,860	700	2,560	including 50 ha of Fishpond
Total	23,580	11,420	35,000	

3.4.2 Agricultural Production

(1) Crop Production

The main crops produced in the Study Area are sugarcane, rice and melon. Besides, corn, watermelon, beans and chili are also grown at a fairly large extent. As commercialized fruit, Mango is produced, with the sowed area of 230 ha.

According to the statistics of MAG, the planted area of sugar cane is 12,100 ha, and the total cane production reaches 801 thousand TM, with a yield of 66 TM/ha. About half of the cane production is produced by the CATSA, which is a large-scale enterprise farm, located on the left bank of the Tempisque River in the Study Area, as well as the owner of a sugar mill. This company supplies the harvest and transportation services to numerous small and medium farmers on the basis of contract; consequently CATSA ensures the raw materials for its manufactory production. Viejo, another large-scale farm that is located outside of the Study Area, is also an owner of a sugar mill and supplies the same services on the basis of contract in the Study Area.

The average yield of sugarcane of the large-scale enterprise farms located on the left bank is about 70 TM/ha while the yield of small to medium-scale farms located on the right bank is about 60 TM per hectare. Moreover, 100 to 125 kg of raw sugar is produced from 1 TM of cane.

The planted area of rice during the rainy season is 6,560 ha; the production is 26,000 TM of unhulled rice, and the average yield is 4.03 TM/ha. Large-scale producers carry out their production even during the dry season in the areas capable of irrigation(around 1,200 ha); their average yield is 4.84 TM, which is 25% higher than the average yield during the rainy season. Rice is mainly planted by medium and

large-scale farmers as well as by the organization of small farmers in shared lands. The large-scale farmers on the left bank of the river attain an average yield of 4.13 TM in the rainy season and 5.52 TM in the dry season. These results are relatively higher than the yield of small and medium-scale farmers.

Though the planted area of melon is only 2,870 ha, melon is considered as one of the three major crops in the area , for the income by the product is very large. Its total production is 78 thousands TM approximately, which implies an yield of 27 TM/ha. It is cultivated as an exporting crop and its production is increasing annually. Because melon production is high-cost high-return, it is mainly practiced by large-scale farmers. Nevertheless, recently, some small and medium-scale farmers are about start melon plantations for export or for local markets under contracts with big companies. In addition, the production of watermelon, chili, green pepper and tomato is increasing because of their high profitability. On the other hand, corn and beans are produced by small farmers for domestic consumption. The following chart summarizes the planted area, production and yield of the main crops:

Planted area of main crops in the Study Area (ha)

Zone	Rice (Rainy season)	Rice (Dry season)	Rice (Total)	Sugar cane	Melon	Corn	Mango	Water-melon	Beans	Chili	Pasture
Right Bank of Tempisque River	3,000	340	3,340	5,950	2,020	200	110	80	80	25	9,275
Left Bank of Tempisque River	2,370	850	3,220	6,150	850		120				1,360
Total	5,370	1,190	6,560	12,100	2,870	200	230	80	80	25	10,635

(Source: MAG)

Main crops production in the Study Area (tons)

Zone	Rice (Rainy season)	Rice (Dry season)	Rice (Total)	Sugar cane	Melon	Corn	Mango	Water-melon	Beans	Chili
Right Bank of Tempisque River	10,873	1,070	11,943	362,950	59,600	221	715	950	65	325
Left Bank of Tempisque River	9,800	4,692	14,492	437,990	18,120		900			
Total	20,673	5,762	26,435	800,940	77,720	221	1,615	950	65	325

(Source: MAG)

Yield of main crops in the Study Area (ton/ha)

Zone	Rice (Rainy Season)	Rice (Dry season)	Rice (Total)	Sugarcane	Melon	Corn	Mango	Water-melon	Beans	Chili
Right Bank of Tempisque River	3.62	3.15	3.58	61	29.5	1.11	6.50	11.9	0.82	13.0
Left Bank of Tempisque River	4.13	5.52	4.50	71	21.3		7.50			
Average	3.85	4.84	4.03	66	27.1	1.11	7.02	11.9	0.82	13.0

(Source: MAG)

(2) Livestock farming

Pastures prevail on the upper lands near the hills. The total area of 10,635 ha, follows the planted area of sugarcane. Yet, with the current low management techniques consist basically in using natural pasture, intensive management is nearly impossible. The total number of cattle heads in the Study Area is estimated as approximately 8,450 with a 0.79 head/ha average. Likewise, pig and poultry make up a great deal of heads, although the exact figures remain unknown. The following chart presents the number of cattle:

Pasture area and cattle in the Study Area

Zone	Area (ha)	Number of Feeding Cattle	Feeding Capacity (head/ha)
Right Bank of Tempisque River	9,275	7,230	0.78
Left Bank of Tempisque River	1,360	1,220	0.90
Total	10,635	8,450	0.79

(Source: MAG)

Parasite control is the most important in management of pastured cattle. In addition, supplement of vitamins and minerals are also important. 18 kg of urea/head/year with molasses and salt are supplied for nutritional supply. Milk production per head is 5 to 7 kg daily.

3.4.3 Conditions of Farming

(1) Classification of small, medium, and large-scale farmers and characterization of their management

The criteria used for ranking small, medium and large-scale farmers differ between each institution. Therefore, it is a difficult task to apply a single definition on each group. However, it is tended to state the classification based upon management capability besides of the size of land. The MAG has not set a meticulous classification of different kinds of farmers. The reference set by MAG is on specific management areas depending on crops. For instance, regarding sugarcane and rice, a small farmer would be the one with less than 20 ha, while the rest are either medium or large with no particular classification; some say that one owning more than 100 or 150 ha is a large-scale farmer. Melon production implies a high capital investment and generates important profits; it is exclusively grown by large farming companies, with no regards of the planted area.

Five large-scale farmers prevail on the left bank of the Tempisque River and there are about twenty five large-scale farmers on the right bank. There are no accurate statistics on number of farms, and even ASA has not the exact data. The following chart displays the estimated number of farms according to their size; prepared based upon numerous recent surveys.

Number farms according to size and area of plowed land

Farm Scale	Number of Farm	Total Area (ha)	Average (ha/farm)
Small-scale Farm	830	6,100	7.3
Medium-scale Farm	134	6,680	49.9
Large-scale Farm	30	17,620	587.3
Total	994	30,400	30.6

Medium and large-scale farmers work on their land under an entrepreneurial method by employing many farming laborers. Small-scale farmers with land larger than 5 ha, also work on their land in such a way. In contrast, small farmers with less than 5 ha of land employ one or two hired laborers besides their family as labor force.

(2) Sectional Characteristics of Farming of Small-Scale Farmers in the Study Area

All small-scale farmers in the Study Area are distributed in the right bank of the Tempisque River. The land use of the right bank in the study site may be distinguish, as aforesaid, as plains near the river and undulate areas near the hills. The major products of small-scale farmers differ in these areas. Sugar canes and rice along with a potion of vegetables are grown in the plains, while stocks are raised in the undulate areas with production of small amounts of frijoles and maize for domestic consumption.

Though the lands of small-scale farmers raising stocks are comparatively larger than others, the income is low, due to low productivity. For this reason, many of them wish to switchover to raising sugar cane. However, undesirable soil characteristics of the undulate areas and the shortage of financial resource disables the conversion of farming. The area is also deficient of ground water potential and has distance and elevational differences with the river. Therefore, even the large-scale farmers of the area do not implement irrigation, not to speak of small-scale farmers. On the other hand, the farming of small-scale farmers of the plains near the river are also unstable. The area is unequipped with irrigation facilities, and therefore the harvest of crops such as sugar cane and rice within this area is highly influenced by weather conditions.

(3) Improving Farm Management by Organizing Small-Scale Farmers

Banks tend to provide credits to cooperatives or associations of small-scale farmers that are registered and have demonstrated high profit rates in their production. Besides, the farm mechanization service charge can be reduced down to 10% or 20% if 200 ha of land can be grouped; similarly a 10% discount for inputs and 20% decrease of the labor force cost may also be available. Based on this context, MAG encourages farmer’s organizations. The parceleros in the IDA settlements are organized under the

institution policies; for instance, thirty farmers, each with 8 ha of land, has gathered and made up a 240 ha extension to grow sugarcane or rice under a mechanized, entrepreneurial system. As result, the farmers obtain high profit rates. Though there are organizational processes in other regions, which are not IDA settlements, their bond and consistency are usually less strong than the IDA settlements. In some cases, organizations have been forced to break down due to conflicts of members and disagreements. The IDA is the institution in support of the legal permissions for organizations.

(4) Production Techniques

1) Sugar cane

Planting is carried out at May and harvesting is carried out mainly from December to march. Ratooning is repeated about 5 times. However, the interval of renovation of plants is generally long in this area, and as an extreme case, ratooning is repeated for about 20 times.

The main varieties sowed by large-scale farmers on the left bank of the Tempisque River are CP 702086, SP 701284, SP 716180, NA 5642. These varieties occupy more than 90% of the planted area. In contrast, small and medium-scale farmers on the right bank sow NaCO 310、NaCO 376、Norte Argentina and some SP varieties.

Fertilizers are applied right after ratooning, and also one or two times within 2 months after ratooning. The total amount of applied fertilizer components are 180 kg/ha of nitrogen, 65 kg/ha of phosphoric acid and 35 kg/ha of potash. Generally, small and medium-scale farmers carry out planting, fertilizer application, weed control and pest control with hired laborers, and they entrust harvesting, collecting and transporting of canes to the sugar manufactory. In addition, many farms entrust the land preparation works before new or renewal planting of canes.

Harvesting work is mainly carried out by hand cutting though sugarcane harvesters are occasionally used . Even in CATSA farm where they grow more than 5,000 hectares of sugarcane, harvesting work with sugarcane harvesters only covers 40 % of the fields. Damages of diseases and insects are very few but damage by rats are a major problem. Fungicide and insecticide are sprayed scarcely, and herbicide is often sprayed at the early stage of growth as a mixture of 2 to 3 chemicals.

Irrigation is effective for yield increase of cane. When enough water is supplied at the sprouting stage of the regenerate bud, it is expected that the yield will be more than 100 tons/ha. The price of cane varies depending on sugar contents, and range from 65 to 67 colons per kg of sugar which is obtained from the cane.

The newly planting costs per hectare, for without irrigation and with irrigation, are 242 thousands colons and 258 thousands colons, respectively. The annual production costs for without irrigation and with irrigation, are 263- 277 thousand colons and 325-339 thousands colons, respectively. The following chart summarizes the production costs per hectare:

Production cost per hectare of sugarcane

Items	Without Irrigation			With Irrigation		
	1. Newly Planting	2. 1st year's Harvest	3. 2nd year & after	1. Newly Planting	2. 1st year's Harvest	3. 2nd year & after
1. Labors	111,852	187,765	211,867	128,052	241,174	265,276
1.1 Mechanical Labors	56,656	150,000	156,672	72,856	200,000	206,672
1.2 Manual Labors	55,196	37,765	55,195	55,196	41,174	58,604
2. Materials	115,500	72,071	61,671	115,500	72,071	61,671
2.1 Seed	84,000			84,000		
2.2 Fertilizer	31,500	35,775	35,775	31,500	35,775	35,775
2.3 Herbicide		36,296	25,896		36,296	25,896
3.Others	14,450	3,675	3,675	14,450	12,523	12,523
Total	241,802	263,511	277,213	258,002	325,768	339,470

(Source: Liberia Branch of Banco Nacional)

2) Rice

Rice is usually sowed during the rainy season, in June and July. Then, it is harvested between November and December. Some large-scale farmers also carry out rice sowing during the dry season in areas capable of irrigation; they sow in December and harvest in April. The average yield per hectare is 4 TM approximately, during the rainy season, and 4.8 TM during the dry season. In detail, large-scale farmers on the left bank of the Tempisque River, obtain an average yield of 5.5 TM during the dry season, while small and medium-scale farmers on the right bank obtain 3.6 TM average yield in the rainy season.

The typical rice cultivation method in the Study Area is “secano” method. The field for “secano” method is flat land with slight slope and without border ridges. Seeding is carried out on dried soil and after rainfall the rice sprouts. By this method, growth of rice must rely on rainfall distribution and amount of precipitation and results in constant risk of water shortage.

The planting method is of direct seeding which is carried out by broadcast hand seeding or stripe broadcast seeding with seeders. In addition, aerial broadcast seeding is carried out sometimes by large-scale farms. Fertilizers are also applied by hand, by fertilizer applicator or by aerial application. Basal application is carried out before seeding or at the same time of seeding using compound fertilizers such as 10-30-10 or 12-24-12, and top dressing with urea is carried out 1 or 2 times. Total amount of applied fertilizer components per hectare is 130 kg of nitrogen, 40 kg of phosphoric acid and 40 kg of potash.

The main variety of crop is CR 1113. Yet, some other varieties are planted such as CR 1117 or CR 5272. The main insect pests are rice Stem borer, Stink bugs, Armyworms and Plant hoppers, and diseases are Blast, Sheath blight, Helminthosporium leaf spot and Rice hoja blanca virus. Insecticides are sprayed 1 or 2 times complying to necessity, and fungicide is generally sprayed once. Herbicide is sprayed once at the early stage of growth as mixture of 2 to 3 chemicals. 65 % of the 60 thousand colons spent for agro-chemicals cost is occupied by herbicides and 25 % and 10 % are occupied by fungicides and insecticides, respectively.

The organized small-scale farmers generally carry out weed control and pest control using knapsack power sprayer with hired laborers, and they entrust other works such as land preparation, basal application of fertilizer, seeding and harvesting to contractors. Large-scale farmers have machinery and carry out farming practice with laborers. Medium-scale farmers generally entrust work to contractors.

The harvested paddy is collected and transported to rice mills by entrusted transporters. The sale price of unhulled rice is 85 colons per kg, which is readjusted depending on the level of impurities, moisture content and the presence of broken rice. Production cost per hectare is about 257 thousands colons without irrigation and about 301 thousands colons with irrigation. The following chart summarizes the production costs per hectare:

Production cost per hectare of rice

Items	Without Irrigation		With Irrigation	
	Amount (colon)	Rate (%)	Amount (colon)	Rate (%)
1. Labors	117,853	45.9	150,784	50.1
1.1 Mechanical Labors	106,233	41.3	135,755	45.1
1.2 Manual Labors	9,296	3.6	12,023	4.0
1.3 Cost of Social Security	2,324	0.9	3,006	1.0
2. Materials	134,891	52.5	134,891	44.8
2.1 Seed	24,486	9.5	24,485	8.1
2.2 Fertilizer	48,887	19.0	48,888	16.2
2.3 Herbicide	39,690	15.4	39,690	13.2
2.4 Insecticides	6,567	2.6	6,567	2.2
2.5 Fungicide	15,260	5.9	15,260	5.1
3. Others	4,235	1.6	15,484	5.1
Total	256,978	100.0	301,159	100.0

(Source: Liberia Branch of Banco Nacional)

3) Melons

Melons are grown mainly by agricultural companies, which apply trickle irrigation using ground water. Melons require 55 days to grow (from seeding to harvest). Even though it can be sowed all year round, in this region it is cultivated in the dry season, for sugar levels tend to increase during the dry season and high return is brought due to the short supply in the market of the United States. In addition, production cost of the dry season is lower than that of in the rainy season because outbreak of disease is very few. The seeding period is from late October to late March.

Fertilizers are applied between 20 and 30 days after seeding. The amount of applied fertilizer components per hectare are 150 kg of nitrogen, 130 to 135 kg of phosphoric acid and 130 to150 kg of potash. In addition, foliar application including boron, zinc, calcium and magnesium etc. is applied.

The yield per hectare is about 1,200 to 1,500 cases (net weight of a case of Cantaloupe is approximately 18 kg) and the products are exported to USA and European countries with the price of 10 to 12 US dollars per case.

Production cost per hectare for melons are approximately 1.8 million to 1.9 million colons as presented in the following chart:

Production cost of melon per hectare

1. CANTALOUPE			2. HONEY DEW DORADO		
Items	Amount (colon)	Rate (%)	Items	Amount (colon)	Rate (%)
1. Labors	395,488	20.6	1. Labors	386,022	21.4
1.1 Mechanical Labors	217,152	11.3	1.1 Mechanical Labors	221,052	12.2
1.2 Manual Labors	178,336	9.3	1.2 Manual Labors	164,970	9.1
2. Materials	913,545	47.5	2. Materials	878,790	48.7
2.1 Seed	123,552	6.4	2.1 Seed	155,563	8.6
2.2 Fertilizer	99,767	5.2	2.2 Fertilizer	118,378	6.6
2.3 Agro-chemicals	165,266	8.6	2.3 Agro-chemicals	222,612	12.3
2.4 Other materials	524,960	27.3	2.4 Other materials	382,237	21.2
3. Others	614,490	31.9	3. Others	539,922	29.9
Total	1,923,523	100.0	Total	1,804,734	100.0

(Source: Liberia Branch of Banco National)

4) Vegetables

Vegetables are grown intensively by some active farmers. Due to the high returns, many small and medium-scale farmers are showing interest on engaging in growing vegetables. Currently, there are eight places in the Study Area where small irrigation projects are being carried out in constructions set up by SENARA during the last two or three years. These facilities were later transferred to MAG. Most of these projects consist on the production of vegetables for small groups integrated by three or four small farmers.

Small Scale Irrigation Project in Carrillo Canton

Project	District	Irrigation Area (ha)	Project Cost (Colon)	Date of Start
Coopecarrillo 1	Belèn	5.0	2,030,000	Mar., 1998
Coopecarrillo 2	Belèn	5.0	1,016,634	Jul., 1999
G. San Miguel 1	Belèn	5.0	4,585,877	May., 1999
Los Molinos	Belèn	4.0	1,726,140	May., 1999
La Piragua	Belèn	10.0	3,060,654	Jul., 1999
San Blas	Belèn	8.0	Riego construcción 2,749,823 Casa de plástica 7,000,000	May., 1999
Artolita	Belèn	2.0	883,215.00	May., 1998
Colegio Carrillo	Belèn	5.0	1,708,034.50	Ene., 1999

The main vegetables are chili, green pepper, tomato and watermelon. Cucumbers, melons, ayote(squash), and corn are also grown. The following chart presents an example of a cropping model of the main vegetables:

An example of cropping model of main vegetables

Item	Green pepper	Chili	Tomato	Watermelon
Month of Seeding	November	September	December	Oct.～Nov.
First day of Harvest*	70 days	3 months	70 days	2.5～3 months
Harvesting period	3 months	7 months	3 months	1 month
Yield (kg/ha)	18,000	15,000	18,000	14,000

*: The number of days or months from seeding

The applications of fertilizers are remarkably large in comparison with sugarcane and rice. The application of agrochemicals is also four times more than rice leading the cost to rise to 240,000 colons. 70% of the agrochemicals are occupied by fungicide, 20% by insecticide and 10% by herbicides.

Application amount of fertilizers for main vegetables (Amount of elements, kg/ha)

Fertilizer Component	Green pepper	Chili	Tomato	Watermelon
Nitrogen	223	150	375	81
Phosphoric acid	258	88	567	61
Potash	173	200	175	107

Out of these vegetables, chili and melon which are the export crops, has the market assured by the contract with the trading companies of San José. For the other vegetables, most of the farmers sell over the products to the middlemen in their farms, although some farmers carry the products directly to the market of Santa Cruz. On the other hand the organization called the FECAP has established a system of purchasing crop and selling it mainly to hotels and restaurants in the tourist areas, with a commission of 42%. Once it is possible to obtain large production in the Study Area, it is expected that the farmers will associate with this system. The production costs per hectare of the main vegetables are shown in the following chart:

Production cost per hectare of main vegetables (colon)

Item	Green pepper	Chili	Tomato	Watermelon
1. Labor contract(machinery)	48,000	33,000	48,000	52,000
2. Seed bed	57,290	0	36,953	0
2-1 Labor cost	45,124		25,437	
2-2 Materials	12,166		11,516	
Seed	9,250		8,400	
Fertilizer	842		866	
Fungicide	1,772		1,834	
Insecticide	302		416	
3. After transplant	1,038,360	506,180	1,714,997	417,894
3-1 Labor cost	677,268	245,769	1,022,907	165,624
3-2 Materials	361,092	260,411	692,090	252,269
Seed		9,250		72,174
Fertilizer	132,100	118,000	177,272	38,120
Foliar	16,240	9,874	43,000	4962
Fungicide	134,580	28,512	426,368	67,217
Insecticide	48,810	72,115	32,560	19,416
Herbicide	29,362	22,660	12,890	50,380
4. Others	48,250	480,000	126,625	13,590
Total	1,191,900	1,019,180	1,926,575	483,484

(Source: SEPSA, Executive Secretariat of Agro-pastoral Sector Plan)

In addition to the abovementioned, there are some groups of small-scale farmers who raise and sell seedlings using green houses.

5) Mango

Main producers of mango are the large-scale farmers. The planted areas by small and medium-scale

farmers are only 40 ha out of the total of 230 ha planted areas in the Study Area.

In spite of the necessity of improvement in technologies of production, harvest and post-harvest for the production of international commodities, with export beginning to European markets, these technologies are still insufficient for the small and medium-scale farmers.

Generally, scions of trees with suitable nature are used to graft mango trees. However, seedlings, at times, are also used. Pruning and training are generally practiced during 3 years after planting, and many of the trees are left alone after the 4th year. Therefore, though standard planting space is 7 to 17 meters, it tends to be planted with more wide spacing. Recommended application amount of fertilizer components per tree are 0.5 kg of nitrogen, 0.15 kg of phosphoric acid and 0.5 kg of potash for the young tree which have began fruit production, and 1-1.5 kg, 0.3-0.4 kg, 1- 1.5 kg respectively for a mature tree. Fruit bearing age is about 4 to 7 years in for the seedlings and after 3 years of grafting for the grafted trees. Bearing period is about 140 days and harvesting season is generally from April to September. It is possible yield more than 30 tons of fruits per hectare with good management practices. However, the actual average yield in the Study Area is only 7 tons per hectare. In addition, harvested fruit is not kept well during marketing process due to inappropriate technologies of harvest and post-harvest. Therefore, the improvement of technologies of production, harvest and post-harvest is necessary.

6) Livestock farming

Management of livestock farming is categorized into four big categories:

(a) *Cria* (Breeding): Consists of breeding meat cattle and dairy cattle, and selling the calves at certain age. The management of the farm requires thorough awareness of the socio-economic conditions, technology on reproduction and feeding etc., as well as a large capital.

(b) *Desarrollo* (Development = Fattening): Consists of buying calves weighing 200 kg from "*Cria*" and fattening them up to approximately 450 kg for trade. The techniques are simple and operation is easy. Therefore, most small-scale farmers practice by this way.

(c) *Leche* (Milk = Dairy): Consists of raising dairy cattle for milking and selling milk.

(d) *Doble proposito* (Double purpose): Consists of combinations of the above-mentioned categories. The operation requires deeper knowledge, higher technical ability, know-hows in administration and management as well as large capital.

Pastures for the small and medium-scale farmers of the Study Area consists of natural grass and because it is affected by arid climate in the dry season, the productivity is low: annual fresh yield is only 8 tons per hectare and its feeding capacity is only 0.8 heads per hectare. It requires 12 months to fatten a calf of 200 kg to 450 kg, using small amounts of urea, molasses and minerals (complementary food intake). On the other hand, according to the cases observed around the Study Area, it is known that production of highly nutritious pasture with an average yield of approximately 30 TM per hectare is possible when establishing artificial grassland provided of irrigation with the investment of approximately 90 thousands colons per hectare. If a small amount of supplementary food intake is added, it is possible to fatten an average of 2 calves from 200 kg to 450 kg in seven months per hectare. The following is a reference of the production cost per hectare, based on an exemplification of the "*Desarrollo*".

Item	Natural grassland* (0.8 head/ha)	Tame pasture** (2 heads/ha)
1. Establishment and maintenance of pasture	0	49,120
A. Establishment redeem (10% of total cost)	0	4,690
B. Maintenance	0	44,430
Fertilizer application		15,000
Disease control		1,000
Weed control		20,100
Water charge		8,330
2. Feeding and management	109,704	119,835
Feeding(hay, concentrated feed)	27,120	25,200
Supplemental feed (molasses, mineral)	9,125	13,790

Item	Natural grassland* (0.8 head/ha)	Tame pasture** (2 heads/ha)
Medical supply	824	1,200
Maintenance of fence	0	26,830
Manual labors	52,925	30,995
Family labors	19,710	11,340
3. Purchase of calves	62,160	153,400
4. Interest for finance (16%)	9,946	24,864
Total	181,810	338,739

*: Without irrigation, 12 months for fattening, **: With irrigation, 7 months for fattening
(Source: SENARA)

Moreover, there are farmers who do not grow pasture all year round. Instead, they reap the pasture during the rainy season, dry it and pack it using packing machines (50 kg each pack) and trade them during the dry season.

3.4.4 Market of Agricultural Products.

The market of agricultural products in Costa Rica is being gradually penetrated by the free trade basis of WTO. The market is separating from government control and is starting to tune in with the international market. Moreover, the crops assumed to increase in production due to this project are the crops mainly produced in the Study Area; sugar cane, rice, melon and vegetables.

The main agricultural exports of Costa Rica are traditionally bananas and coffee. As for new items there are fruits, ornamental foliage plants and flowers. In fiscal year 1999, the amount of export was 630 million dollars for bananas, 310 million dollars for coffee, 210 million dollars for fruits and 120million dollars for ornamental foliage plants and flowers. The export of sugar in the same period was only 30 million dollars and does not even reach the export of 53 million dollars for beans and vegetables.

Costa Rica imports four kinds of major crops. In fiscal year 1999, the amount of import for these crops were 35 million dollars for wheat, 48 million dollars for maize, 32 million dollars for frijoles and 13 million dollars for rice. These figures indicate that trade amounts of rice and sugar are relatively low.

The government controls the domestic market to maintain the advantage of sugar in the international market, and on the other hand, is starting to loose power upon the rice market.

(1) The Market

1) The Sugar Market

The market is controlled by LEICA in order to level the international and domestic price. Consequently, the domestic price of sugar in Costa Rica is constantly the same as that of the international market.

The planned harvest of sugar for the harvest stage of fiscal year 2001-2002 is 320 thousand tons, consisting of 72% for export and 28% for domestic consumption. 17%of the export is sent to the USA based on trade agreements. The price of sugar in the international market has been decreasing from approximately US$0.88/kg in 1980 to US$0.18/kg in 1999, and is assumed to keep stable as US$0.17/kg in 2005 and US$0.18/kg in 2010 according to the estimations of the World Bank. Therefore, considering the price of sugar and the estimation of situations of export, it is assumed that the increase of sugar production by the small and medium-scale farmers will not bring disorder to the regional and international market, as long as there are changes in the inter-district balance of domestic production.

2) The Rice Market

The demand and supply of rice in Costa Rica is summarized as follows:

In fiscal year 1999-2000, the planted area of rice in Costa Rica was 680 thousand hectares. The production of unhulled rice was 2,820 tons with the unit production of 4.17 tons/ha. The amount of unhulled rice produced is equivalent to 1,880 tons of rice. On the other hand, the assumed domestic demand of rice is 54kg/person, summing up to 2,160 thousand tons with 4 million as the national population. Thus, 28 thousand tons of rice, representing 13% of the demand, is the necessary import.

As for the domestic market of Costa Rica, the shortage of rice for fiscal year 2000-2001 was assumed to be 38 thousand tons, According to the Bureau of Rice of the Ministry of Agriculture. However, there were 15 thousand tons of surplus wherefore 53 thousand tons of rice were imported by the traders.

With the usual stock rotation of two months delayed to 3-5 months, in many cases traders refused to buy unhulled rice from the farmers. The imported rice is mainly produced in Louisiana, imported as unhulled rice and debarked at the port of Caldera on the Pacific coast.

On the other hand, for the price of rice in the international market, the FOB price of rice handed at the port of Bangkok in Thailand, has decreased from US$570/ton in 1980 to US$240/ton in 1999. According to estimations of the World Bank, the price will be moving to US$264/ton in 2005 and US$255/ton in 2010. The present buying rates of rice at the rice mills in the Study Area is approximately US$250/ton, while the price of imported rice is US$105.0 to US$102.5/ton by the FOB of unhulled rice used by the bureau of rice of MAG, handed at the port of New Orleans at Nov. 14, 2001. Though these figures are not to be indiscriminately compared, due to the necessity of considering international markets situations and differences in quality, it still may be said that the future trend of descending f arm price is unavoidable.

3) Mango

The planted area of mango in Costa Rica in fiscal year 1996 was 5,800 ha, while Guanacaste held 1,300 ha. The largest growth area in the country is the Pacifico Central centering Orotina, San Mateo. Recently, the Puntarenas provinces of Lepanto, Cobano and Paquera located in the tip of the Nicoya peninsula are rapidly growing. Half of the planting in Guanacaste is done by L&S Corporation.

The unit production of mango is 3.5-4tons/ha and 20% of the production is lost as defectives. The rate of export is 6% and mostly sent to Germany. For these reasons, the CNP in 1995 evaluated mango as a potential export product.

(2) The Marketability of Neighboring Tourist Sites

Hotels with the total capacity of approximately 5,000 rooms are already built in the province, in the neighboring tourist sites including the costal areas. 400 thousand foreign tourists visit the sites each year, and the hotel rooms are mostly full in Christmas season.

Though the touring season is only slightly longer than four months, from December to April, the increase of food demand in this period has prospect of a new market when matching the period of cropping. However, some aspects must be considered: these demands have seasonal irregularity, the payment of the hotels are regularly delayed for more than a month, high quality demands as the products are for tourists.

3.4.5 Irrigation and Drainage Conditions

(1) General conditions in the Study Area

The midstream basin of the Tempisque River, that is a part of the Study Area, is the granary area of Costa Rica, due to its planar topography of alluvial formation. Within this area, agriculture has been active for many years. However, without irrigation, the shortage of water with only 100 mm of precipitation in the dry season (November to May) troubles cultivation of yearly harvested crops. For sugar cane, the prospect of harvest is only 60% when cultivated without irrigation in the dry season.

The source of water used in the dry season in the Study Area is the river waters of Tempisque, Cañas and Liberia, etc., and groundwater. At the moment, water of the Tempisque River is used mainly for rice and sugar cane by means of pumping in 26 places along the river, with an assigned flow of 11 m3/. The following chart indicates the monthly volume of water taken from Tempisque River. In the low water time, there is hardly any water flow near Guinea. As for the tributaries Cañas and Liberia, irrigation of rice is carried out while f water low exists in the low water time. However, the tributaries are small in magnitude and water will be gone by January. The area that has the watering system with river water is approximately of 4,100 hectares in the left bank of the Tempisque River and of 3,460 hectares in the right riverbank, being the total of 7,560 hectares

Unit: m3/sec.

Tempisque River		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DIC
Water taking between La Cueva and Guardia		1.55	1.55	1.55	1.24	0.54	0.31	0.31	0.31	0.31	0.31	0.91	1.33
Flow at Guardia Bridge	Ordinary	16.80	12.12	9.02	7.61	14.72	30.83	21.51	26.73	48.18	63.07	43.28	22.27
	Low-water mark	12.98	10.01	7.66	6.78	6.98	12.06	12.94	13.80	18.14	23.02	18.47	16.40
Water taking between Guardia and Guinea		9.49	9.49	7.44	6.69	4.96	4.36	4.36	4.36	4.36	4.45	4.58	9.49
Flow at low part of Guinea	Ordinary	7.31	2.63	1.58	0.92	9.76	26.47	17.15	22.37	30.04	58.62	24.81	12.78
	Low-water mark	3.49	0.52	0.22	0.09	2.02	7.70	8.58	9.44	13.78	18.57	13.89	6.91

In the right bank of the Tempisque River, where ground water is abundant, there are many wells used for the watering systems. In this area cultivation of melon with trickle irrigation is mainly practiced by large-scale farmers with large funding ability.

There are approximately 30 wells in this area, set with rights of water. The total flow of pumping reaches 1,030 liters per second for the cultivation of melons in 1, 230 hectares, rice and sugar cane in 200 hectares, respectively.

Summarizing the abovementioned data, irrigated areas of the Study Area has the total of 9,875 ha consisting of 8,245ha utilizing river water and 1,630ha utilizing ground water. These areas utilize 12 m3/sec of water from rivers and wells. The areas of irrigated lands classified by the sources of water are as follows:

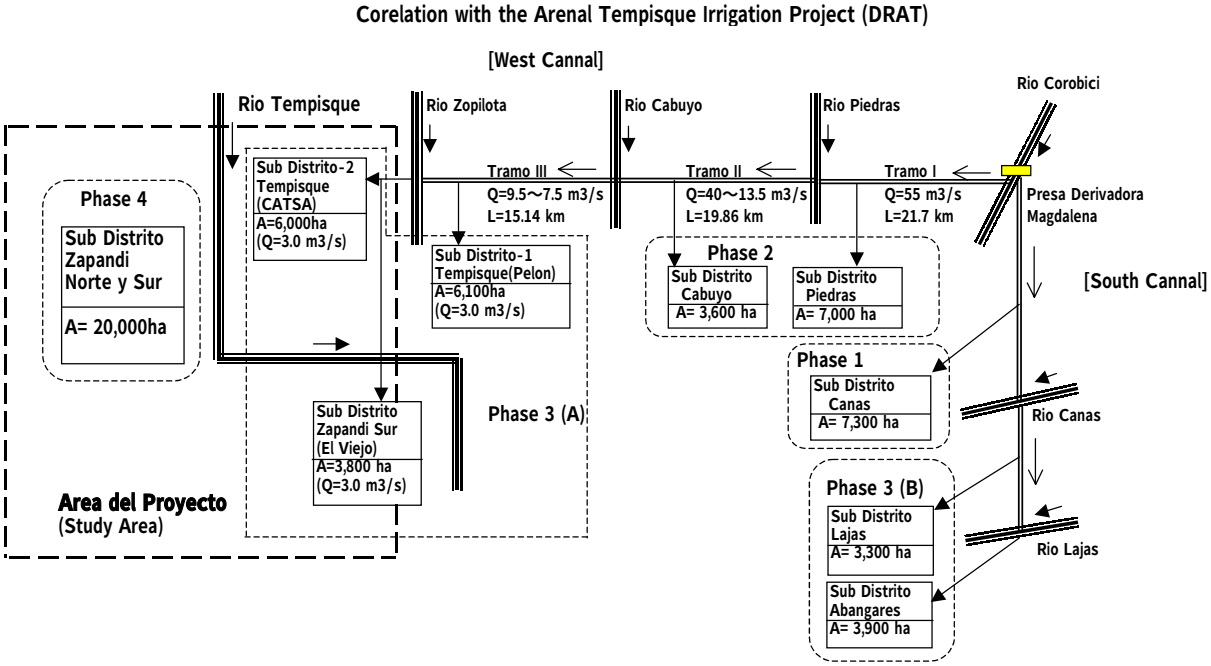
Unit: Hectare

Area	Irrigated land		Seasonal crop land	Total
	Rivers	Underground water		
Left bank of Tempisque river	6,700	40	3,300	10,400
Right bank of Tempisque river	1,545	1,230	17,225	20,000
Total	8,245	1,630	20,525	30,400

In the latter half of the rainy season (between September and October), the average precipitation exceeds 600 mm. This corresponds to 30% of the annual precipitation and leads to the frequently occurring of floods in the low lands and planes. The basin of the Palmas River is frequently flooded due to its topographical depression, and with the highway (Filadelfia-Santa Cruz) crossing the river working as dike to flood the upstream part of the basin. The low basin of the Palmas River, has conventionally formed swamps, and it often suffers damages of bad drainage. There are also problems of bad drainage in the flat and low areas of the left bank of the Tempisque River. However, the Properties of the big proprietors that prevail in the areas, have built drainage systems with their own finance, with 3 stations of pumping for drainage at the point of confluence with the Tempisque River.

(2) Correlations with the Arenal-Tempisque Irrigation Project

The Study Area is located in the area covering the Phase 4 of the Arenal-Tempisque irrigation project as indicated in the following figure. This project was onset in 1980 with the financing of Inter-American Development Bank (IDB). The Phase 1 of the project was to utilize the water of Arenal lake used for hydraulic power generation as the water resource for irrigation. The area irrigated by this project by the year 1996 were, 7,300 ha for Cañas in Phase1, and the total of 10,600 ha in Phase 2 which were 7,000 for Piedras and 3,600 for Cabuyo. At first, the planned area of irrigation was 60,000 ha. However, with the distribution of water from the hydroelectric power plant decreasing from 70 m3/s to 46 m3/s, it was reluctant that the area to be irrigated was reduced to 40,000ha. At Phase 3, the circuit of the west canal was extended to the Tempisque sub area, and the construction of the conduit with the capacity of 15.0m3/s, containing the 9.0m3/s for three large-scale farmers (3.0m3/s each) was begun in Dec. 2000.



The itemization of the irrigation areas of the Arenal Tempisque irrigation project, after changing of the plan are as follows:

The Arenal Tempisque Irrigation Project units：ha

	West canal circuit		South canal circuit		Total
Phase1		-	Cañas sub area	7,300	
Phase 2	Piedras sub area	7,000			
	Cabuyo sub area	3,600			
Area equipped for irrigation		10,600		7,300	17,900
Plan for Phase 3	San Ramón sub area	1,100	Lajas sub area	3,300	
	Tempsique sub area		Abangares sub area	3,900	
	・Pelón	5,000			
	・CATSA	5,000			
	Zapandi sub area				
	・El Viejo	3,800			
Sub Total		14,900		7,200	22,100
Total		25,500		14,500	40,000

Therefore, for Phase 3, the water resource of Arenal lake will be sufficient for irrigating the left bank of Tempisque River with the large-scale farmers. However, a new source of water will be necessary for the irrigation of the right bank of Tempisque River, which is the area of Phase 4, where farmers of various scales practice.

(3) Current State of Water Management

The area in the Arenal Tempisque irrigation project is called “Distro”(sub areas). The management of irrigation water is usually done by the SENARA up to the entrance of the fields of each farmer. The farmers using irrigation water pays 14,370 colons/ha/year (results from 2001) as water charges. Costs for administration, O/M and water rights are contained in these water charges.

However, irrigation associations are seen for some of the parts of the sub areas, and in cases of these associations distributing water to the associates, charges of water management are sometimes returned.

In the Study Area, there are still no positioning of sub areas, and a portion of large and medium-scale farmers owning financial ability practices irrigation by individually obtaining water rights of river water

(Tempisque River, Cañas River, etc.) and ground water from the MINAE.

There are large yearly changes in the amount of river water. Especially in the dry seasons, there are cases of river water falling below the amount of water rights. In this case, MINAE controls the monthly uptake. Therefore, in years of droughts, the farmers reduce the area being irrigated and improves efficiency of water by using techniques such as trickle irrigation.

The usage of ground water in the Study Area is largely categorized as follows:

- The large-scale farmers using ground water for irrigation of melon for export
- The small-scale farmers using ground water for small-scale irrigation of vegetables through application to SENARA

The melon production of large-scale farmers are done only in the dry season. The irrigation of these fields are done by measures of trickle irrigation with strict rotation and good efficiency. There are about 6 blocks of Small-scale irrigation practiced by groups of small-scale farmers. In these blocks, water management is done by groups of 5 to 10 farmers each delivering approximately 1 ha of land. A well is equipped in the center of the aggregated land and vegetables such as watermelons and chili are produced cooperatively with trickle irrigation or irrigation using hoses. The depth of the wells are 30 to 60 meters and the uptake is from 5 l/sec to 150 l/sec.

3.4.6 Agricultural Infrastructure

In the Study Area, some storing centers for agricultural products, such as sugar canes, melons and rice are dispersedly located surrounding the large-scale farmers. There are also two sugar mills; CATSA that this in the left bank of the Tempisque River, and El Viejo that is located near Guinea.

The characteristics of these sugar mills are as follows:

Company	Capacity (tons/days)	Annual production (tons)	Recollection area (ha)
CATSA	6,000	720,000	13,000
EL VIEJO	5,200	624,000	8,800

The cultivation of melons are practiced mainly by the large-scale farmers capable of investments for facilities. These farmers make contracts of producing melons with foreign companies as Del Monte, and two big cultivation areas exist near Sardinal and Filadelfia. “Melones de Costa Rica”, which is one of the cultivation area, is located in the south of Filadelfa, cultivate some 700 hectares in both riverbanks of the Tempisque river. 75 % of their production is exported for the United States and 25 % for Europe. The sorting facility of melons, which is located beside the Tempisque River, has a capacity of 234 tons per day, packing 13,000 boxes of 18 kilos daily. In the export period (from January to April), 250 women from the surrounding communities work in this facility to obtain economic revenues.

As for the cultivation of rice, there are two big plants in the Study Area where the harvested rice is processed. One is near Guardia, in the upstream, and the other near Belén, in the downstream.

Also, near Palmira, there is a company that sells agricultural inputs such as seeds of rice and fertilizers.

3.4.7 Supporting Systems for Farmers

(1) Technical Supporting

The Chorotega Regional Direction of the Ministry of Agriculture and Livestock Farming (MAG) supplies technical advice and assistance mainly to small and medium-scale farmers in cooperation with the Regional Offices of CNP, INA, IDA, SENARA and IMAS etc.

The Regional Direction of MAG consists of 4 technical divisions, Research Div., Extension Div., Plant Protection Div. and Animal Hygiene Div. the Divisions carry out improvement of crop production technology, planning of extension, plant protection management, animal disease prevention and animal quarantine, respectively. In addition, Agriculture & livestock Service Agency (ASA), the lower branch

of the Extension Division is established at each canton. Carrillo Office of ASA is located at Filadelfia in the Study Area and supplies technical services to farmers. Staff of CNP resides there and works in collaboration with staff of ASA.

Main works of the ASA are as follows: ① extension of crop production techniques, ② extension of livestock feeding techniques, ③ promotion of farmer's organizations, ④ formation and evaluation of development projects. When technical problems difficult to be solved by ASA outbreaks, Local Institutes Technical Study Team (ETIL), consisting of the above-mentioned institutes and representative of farmers deals with the problem.

Technical extension service is generally conducted for groups of farmers, for example, members of cooperatives, neighborhood farmers, groups of farmers producing special crop such as watermelon or tomato. Generally, there are no guidance for individuals. Each group is lectured and receives practical guidance on the field. The services of the above-mentioned institutes are as follows: CNP supplies market information, studies and analyzes project and gives technical assistance through extension programs. INA conducts training of farming techniques for farmers. IDA distributes farmlands for settlers and gives permission for establishment of the incorporated farmer's organizations. SENARA provides advice on the maintenance and management of irrigation and drainage facilities. IMAS assists to build rich society through the finance for small projects and the improvement of diet.

The main target area of the ongoing project "PRODAPEN" is the Nicoya peninsula including Carrillo canton which occupies most of the Study Area of this study. The project is implemented through MAG, financed by the UN and Central Agriculture Bank of Costa Rica etc. The main purpose of the project is the development of personnel. The Project leads the farmers to organize small groups and voluntarily establish development plans. The project mediates necessary finance and dispatches trainers to the organization for training. The project respects the independence of the minds of farmers and assists them in indirect measures.

On the other hand, some NGOs supply assistance including technical advice and finance.

(2) Agricultural Credit

1) The national Level

Recently, in the formal banking system, the sectors of agriculture, livestock and marine products have been losing the importance as a lending target. In 1990, the sectors held 18.3 % of total credit given, whereas in 1999, the rate decreased to 5.6 %. The major reason behind the phenomenon is that the policy had been seeking the efficiency in the formal financial system. Demand on credit also had been decreasing owing to high interest rate and its changeable nature. Reduction of insurance on production had also affected the demand.

The central bank, with the government approval, carried out in 1994 the bailout of the 'Banco Anglo Costarricense', a state bank, which collapsed in result of financial largess. Since around that time, the government has been trying to tighten loosened finance. An average lending rate in the third quarter of the year 2000, was 24.4 %, about two points lower than the former year.

As of the end of year 2000, the agricultural sector was facing a crisis. Traditional products, especially the sub-sectors of coffee and banana were threatened by the tightened international market conditions, while 3,500 small and medium scaled agro-producers for domestic market have been petitioning the government to restructure their overdue debt payments of 71 million US dollars. These are the situations that have been surrounding agricultural credit.

In spite of the difficulties it has been facing, the central bank granted credit to small and medium-scale farmers, cattle growers and fishermen mainly through the credit programs for rural centers. Consequently, the balance of credit reached nine billion colons in Dec. 1999. The target amount made for 2000 was 14,500 million Colons, 60 % higher than the amount in 1999, and at the same time, a program of micro-finance for the disbursement of 5,500 million Colons was already finished.

Beside of finance through the banking system, the government provides credit through its own agencies.

In1999, CNP, PIMA, SENARA, IDA, INCOPESCA and MAG-PIPA granted credits of 6,510 million Colons to 57,727 producers and their organizations through programs of public institutions, NGO, and development projects.

2) Financial Assistance

In many cases, farmers are unable to engage in production activities unless they are provided with some credits from financial institutions. Presently, there are cases that farmers reduce their production sizes, totally give up production, or to rent their land, for reasons such as difficulties and complexity of the loan procedures and high interest rates. There were no particular conditions set by banks as limiting the minimum production level or conditions that farmers must be members of an organization. Nevertheless, conditions for loans, interest rates, or terms of repayment differ depending on the bank.

The conditions that are common to the national and private banks are, either the crops are insured or the crops are produced on irrigated fields. For insurance on crops (rice) are applied only to irrigated fields, it can be said that the first condition for loan is that the crops are produced on irrigated fields. Furthermore, mortgages and guarantors are required, and interest rates are exceeds 20%.

The repayment terms are 6 months revolving for rice on irrigated land, and for sugarcane it is one year revolving. The terms of repayment are set to suit the production cycle of each crop because irrigation farming is considered to be stable. Once credits are approved, farmers are able to repeatedly use the credit for five years by repaying a certain amount at every harvest. However, if the farmers are unable to repay the agreed amount for some reason, for example, crop failure from plagues attack or break down of irrigation facilities, they have to face difficulties in receiving continuous loans for the next planting. According to an investigation conducted by a certain branch, no cases of repayment stagnation were reported. However, hearing investigation upon farmers indicate numerous cases of households pressured by repayment.

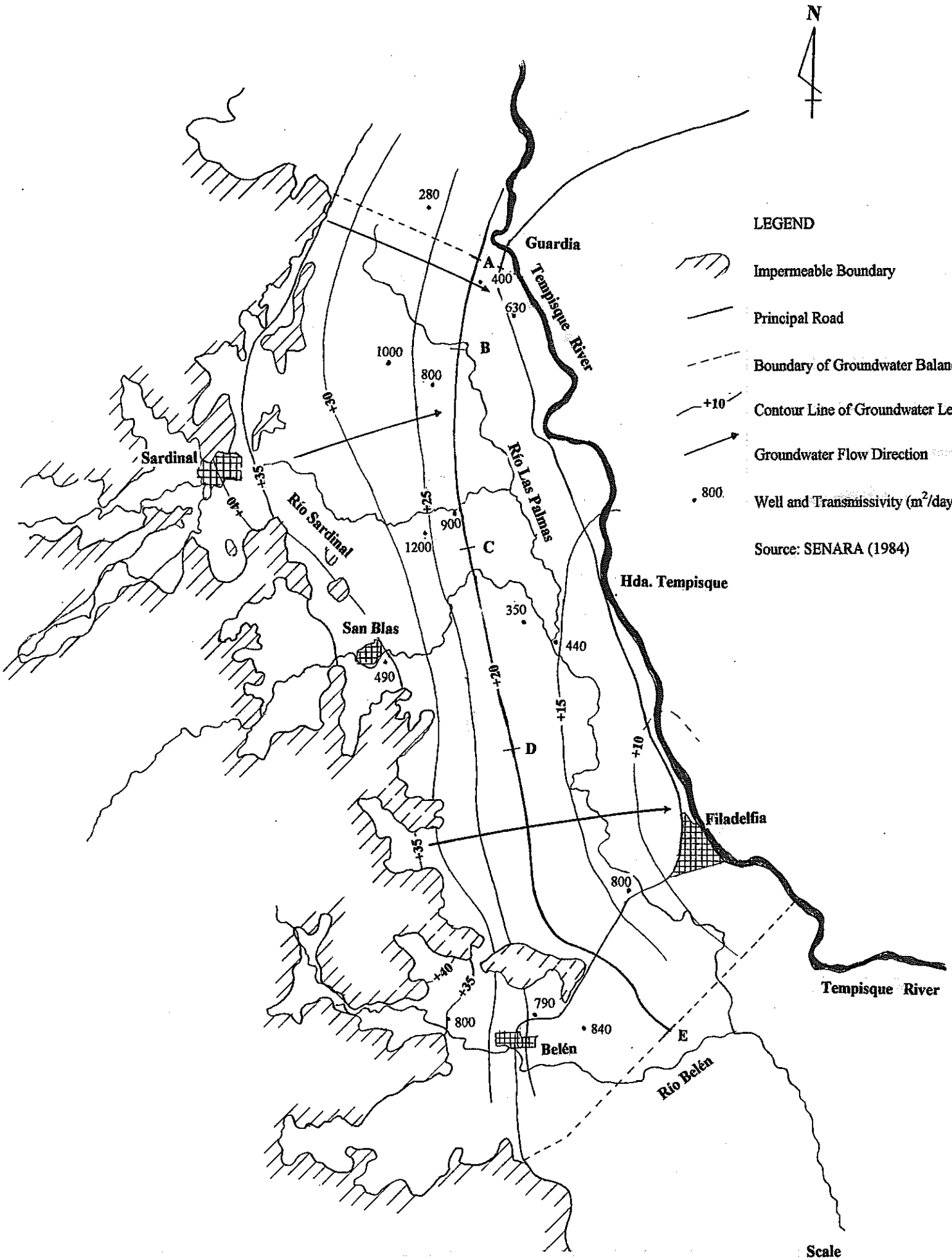


FIG.3-1 CONTOUR MAP OF GROUNDWATER AND TRANSMISSIVITY DIVISION

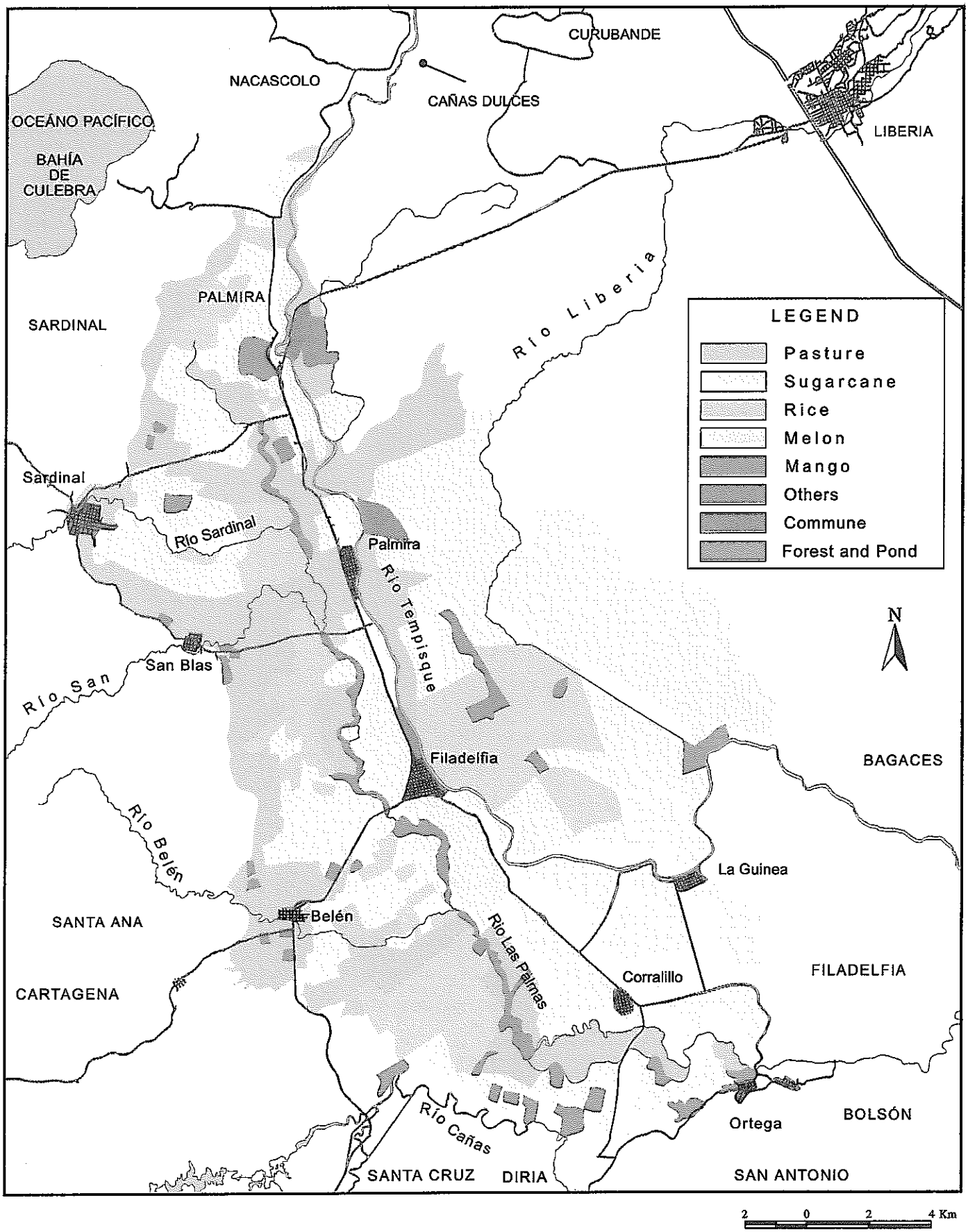


Fig.3-2 Land Use for Crops at Present