CHAPTER 5

AGRICULTURE AND LAND USE

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5.1 Agriculture and Livestock

5.1.1 Role of Agriculture of the Department in National and Regional Economy

Agro-economic indexes are summarized in Table 5.1.1. According to the Table, roles of the agricultural sector of the department in economy are summarized as follow:

(1) The agriculture sector in Santa Cruz plays an important role not only in the regional economy but also in the national economy, contributing 23 % of the total GRDP and 39 % of the agricultural GDP. The importance increased during the years of 1991-95.

(2) The sector of the department much contributes to the foreign currency earning because more than 90 % of the industrial crops; soy bean, sugar cane, cotton and sun flower etc., were produced in the department and contributed 18 % of the total export earnings in 1995.

(3) The main agricultural products in Santa Cruz are soy bean, rice, maize and sugarcane, which shared 31 %, 13 %, 9 % and 8 % of the total crop production of the department in 1995, respectively. The top three crops contributed more than 50 % to the Agricultural GRDP, which was equivalent to about 10 % of the total GRDP.

5.1.2 Role of the Study Area in Agricultural Production of the Department

Due to the high soil fertility endowed by nature, the Study Area has become the center of crop production of the department. The main crops in the area are soybean, rice and wheat, which shared 12 %, 43 % and 41 % of the total production of the department in 1997/1998, respectively (see Table 5.1.2) and the representative cropping calendar is shown in Fig. 5.1.1. During the 1994 – 1998 period, however, the share of soybean decreased from 19 % to 12 % and the share of rice and wheat, on the other hand, increased with expanding their planted area; rice from 33 to 43 %, wheat from 25 to 41 %.

Other crops produced in the area are maize and sunflower, which shared 13 % and 7 % of total production in the department, respectively.

However, the production is fluctuated because their yields in summer, especially soybean, are much affected by flood. Table 5.1.2 shows, for example, that the summer soybean yield in 94/95 was lower than that of the other years.

5.1.3 Agriculture by Sub-area

The Study Area consists of 5 sub-areas and the agricultural features by area is discussed based on the results of interview survey by JICA and the Study Team as follows :

(1) Chane – Pailon Area

1) Okinawa

Agricultural features of the sub-area are discussed based on the data of Okinawa I and II by JICA because the study area includes Okinawa I and a part of Okinawa II.

The agriculture in the area is characterized by well mechanized and large-scale farm management. The average land tenure per family is 421 ha and average number of tractor is 3 per family.

The widest land use is upland area, sharing 76 % of the total area, and the second is grazing land, sharing 9 % (see Table 5.1.3).

Soybean is by far the most widely planted crop in the area, sharing 53 % of the total crop planted area in 1997 (see Table 5.1.4).

Soybean was introduced in the middle of the 1980's. The area was the highest productive area of soybean in the department during 1980s, about 3 ton per hector. However, the productivity has decreased in recent years to 2 ton per hector in 1997 (see Table 5.1.5).

Unarable land caused by salt accumulation in soil has expanded in the area. The deterioration of soil fertility is one of the main problems in agriculture. The causes induced the problems may be as follows:

- Continuous cropping of soybean,
- Deterioration of soil fertility by cropping without application of fertilizer for 40 years,
- Deterioration of soil physical conditions by compaction of soil with heavy agricultural machinery,
- Over development.

The number of livestock and the production of livestock in 1997 are shown in Tables 5.1.6 and 5.1.7. In recent years, chicken and swine farming have expanded sharply to diversify farm income sources for stabilization of the farm economy. The share to the total farm income per family was only 4 % in 1997.

2) Other area

The area is located in the downstream area of Okinawa. The main land use is sugar cane on the left bank of the Chane River, the upland on the right bank of the river, and primary forest in the area along the river.

Small scale farmers are distributed in the upland area, such as Carmen, Caimanes and Puesto Fernabdez etc., where are characterized as very severe flood conditions, but the actual agricultural situation is unknown. Table 5.1.8 shows the results of the farm interview survey about agricultural situations in summer season.

The land is not used effectively because of a high ratio of unused land (28 %) and a low ratio of annual crop area (56 %). The severe flood conditions may reduce the intensity of land use.

The main crop planted in summer season is rice and soybean, which shares 45 % and 40 % of the total planted area, respectively and the third being maize, sharing 14 %. Yields of the crops planted in the area are far below that of the department, because the ratio of harvested area per planted area is law, especially the area planted by small scale farmers less than 20 ha is remarkably low. Main reasons for the low productivity are as follows:

- Inappropriate cropping systems,
- No technical extenuation services.

Livestock is not popular in the area and is mainly raising for self-consumption. The average number raising per family is very low, caw 1.4 heads, swine 1.0 head and chicken 4.6 heads.

(2) San Juan – Antofagasta Area

1) San Juan de Yapacani

The agriculture in the area is well diversified and mechanized. The main farm income sources are rice, soybean, egg and fruits, which shares 32 %, 17 %, 47 % and 3 % respectively. The diversification makes the farm economy stable by

diversification of flood risks and price fluctuation of the products. Average agricultural machine per family is 2.6 tractors and 1.4 combines. Average land tenure is 299 hectors, which is equivalent to 70 percent of Okinawa.

Up land area is the most wide spread land use in the area, sharing 62 % of the total area, and grazing, 11 % (see Table 5.1.8), is the second. The high sharing of grazing land is due to grazing-upland rotation to sustain soil fertility because the natural fertility of soils in the area is rather low.

Main crop cultivated in the area is rice in summer and soybean in winter (see Table 5.1.9). The cropping rotation is well suited for the natural conditions to alleviate flood damages because rice is characterized as water tolerant. These yields have increased, especially rice yield is 1.7 times of the Okinawa, because of the improving of farming technology by the extension, although the original soil fertility is not so high.

San Juan is also well known as a high quality egg production area in the country and the production increased during the past five years (see Table 5.1.9). The number of caw also increased during the same period.

The CAISY puts on effort to accelerate the further diversification by extension of the citrus fruits and macadamia nuts, expanding 900 ha and 200 ha in 1996, respectively.

2) Antofagasta

Antofagasta characterizes fragment and severe floods. The area with more than 50 cm of inundation depth shares almost 80 % of the total area. The area consists of local immigrants and average land tenure is small, 41 ha per family. Main land use is upland crop, sharing 83 % and second being unused land, 15 %.

Main crop cultivated in summer is rice and soybean, which shares 56 % and 44 % of the total planted area, respectively (see Table 5.1.10). Soybean yield in the area is much lower than that of the departmental average, 0.7 t/ha in the area and 1.8 in Santa Cruz. However, rice is not so low compared to the departmental average in 1997/98, 1.9 t/ha in the area and 2.3 t/ha in the province. These show that rice may be more suitable for the natural conditions than others planted in the area. Ratio of harvested area per planted area also proves it: the ratio of rice is higher than that of soybean, 82 % and 52 %, respectively.

Livestock is raising mainly for self-consumption and property. However, egg production is expanding due to the influence of San Juan.

5.2 Land Use and Land Potentiality

5.2.1 Land Use

The Study Area covers 1,207 km^2 of the northern rural region of Santa Cruz, consisting of the Chane - Pailon and the San Juan -- Antofagasta areas as shown in following Table.

STUDY AREA

Drainage Area	Area (km^2)	Province
1) Chane – Pailon	599.6	
Chane	143.7	Obispo Santistevan
Pailon	270.9	Warnes
Okinawa drainage	185.0	Warnes
2) San Juan - Antofagasta	607.3	
San Juan	369.3	Ichilo
Antofagasta	238.0	Ichilo
Total	1,206.9	

Source: Study Team

The land use map, as shown in Table 5.2.1 and Fig.5.2.1, is prepared by the Study Team based on the land use map prepared in the Master Plan Study in 1995 and the supplementary field survey. The characteristics of the land use are as follows:

1) Chane - Pailon
   - Forests distribute mainly in the areas along the rivers, where are characterized as an unarable land with poor drainage,
   - Grazing distributes mainly in an unarable land due to low fertility and severe floods,
   - Sugar cane distributes in an arable land with severe floods, where inundation depth is more than 50 cm in 1997/98 floods,
   - Upland distributes in an arable land with less severe floods.

2) San Juan - Antofagasta
   - Forests distribute in the areas along the rivers, where are characterized as an unarable land due to poor drainage,
   - Grazing distributes in a severe flood area,

- Upland distributes in an arable land with less severe flood.

5.2.2 Land Classification

Land classification in the Study Area is shown in Table 5.2.2 and Fig. 5.2.2 and summarized in Table 5.2.3. The land potentiality is classified into the following five categories.

LAND CLASSIFICATION CATEGORY

Category	Land Classification	Criteria
1	I - III	Land suited for crop cultivation
2	IV	Land marginally suited for crop cultivation
3	V	Land suited for grazing
4	VI - VII	Land marginally suited for grazing
5	VIII	Land unsuited for any agricultural activity

Source: UTD-PLUS

Land classification by area is characterized as follows:

(1) The Chane – Pailon Area

Arable area, from Class I to III, shares about 60 % of the Chane - Pailon area. This means that the agricultural development potential in the area is higher than that of the San Juan – Antofagasta area. However, the area is widely covered by Class V, sharing 33 %, where has a severe limitation for the agricultural activities and is not suited for crop cultivation.

(2) The San Juan – Antofagasta Area

Arable land covers 37 % of the area. Class IV-08 is the dominant class, sharing 47 percent of the area and it characterizes marginally arable land. The class, however, is arable for rice cultivation in summer (rainy season), water tolerant crop, because the limitation is only drainage. Actually, the yield is much higher than that of the provincial average, 3.1 and 2.3 t/ha respectively. Considering the situation, the arable land of the area may cover 83.5 % of the area.

However, in the case of Class IV-07, distributing the Chane - Pailon area, the class is marginally arable because the limitation is water capacity and soil nutrition, which are impossible to improve.

5.3 Land Use Zoning

Land use zoning is prepared based on the information of the land classification by the Projection Plan of National Resources of Santa Cruz (Projecto Plan de Recursos Naturales de Santa Cruz) and the flood conditions in 1997 by the Study Team. The zoning aims to show appropriate land uses for alleviation of flood damage.

The zoning map is shown in Fig. 5.3.1 and the category, consisting of soils, flood depth, existing and recommended land use, is shown in Table 5.3.1. The characteristics of each zone are explained as follows:

Zone 1: The area has no or slight limitations for agricultural land use through a year.

Soils of the area are arable and floods uncommonly occur. The area, therefore, can grow crops and there is no or slight limitations to select crops for cultivation through a year.

Zone 2: The area has moderate limitations of inundation and is restricted crop selection during summer season.

Soils of the area are arable but less severe floods, less than 50 cm depth, commonly occur. The area has limitations for crop selection during the summer to alleviate the flood damage. Water tolerant crops, such as paddy, are suited for the area during summer.

Zone 3: The area has a severe limitation of inundation for agricultural activity during summer season but has no or slights limitations during winter season.

Soils of the area are arable, but severe floods with more than 50 cm inundation depth regularly occur. Floating rice, however, could not be introduced because the flood duration is too short for the cultivation, recording less than one month. A new cropping calendar, avoiding flood season, should be introduced to reduce the flood damage.

Zone 4: The area has medium limitations of soils and is restricted agricultural activity due to low soil fertility through a year.

Soils marginally suit for crop cultivation and the flood does not occur regularly in the area. However, the area does not suit for crop cultivation

commercially because the area can not expect to get high yield due to low soil fertility. The area is recommended to be used for grazing and perennial crops.

Zone 5: The area is unsuitable for crop cultivation because of severe limitations of soils and floods.

Soils of the area do not or marginally suit for crop cultivation and the severe flood, less than 50 cm depth, commonly occurs. The area, therefore, is recommend to use as grazing land.

Zone 6: The area is unsuitable for agricultural activities because of very severe limitation of soils.

Soils of the area are not suited for agricultural use and the area should be used for conservation purposes. Existing forest in the area, therefore, should be conserved.

Distribution of each zone and recommendations for decreasing flood damage are discussed as follows:

(1) The Chane – Pailon Area

The area along the river is covered by Zone 5 and the main land use is forest. The forest should conserve because the area can not use for crop cultivation due to severe floods and poor soil fertility.

Zone 2 shares more than Zone 1 in the Okinawa drainage and Pailon areas although soybean is dominant crop during summer. The area should be converted soybean into the water tolerant crop during summer.

The Chane area is mainly covered by Zone 3 although the area is cultivated soybean and sugar cane. The area should be introduced new cropping calendar because the zone characterizes severe flood and fertile soils..

(2) The San Juan – Antofagasta Area

Zone 2 is the dominant zone in the San Juan area and rice is the most widely planted crop in summer. The land use is suitable for the condition because of slight flood and arable soils.

Most of the Antofagasta area is covered by Zone 3 and the area needs to introduce a new cropping calendar because of severe floods and arable soils.

Zone 6 distributed in the northern area is covered by forest and wet land. The forest should be conserved because the area is not suited for crop cultivation due to poor drainage etc.

5.4 Results of the Interview Survey for Farmers

The interview survey was conducted by the Study Team in order to supplement the existing data and identify the agricultural problems under the flood conditions. The results are shown in the Supporting Report H. Main findings from the survey are discussed as follows:

(1) Relationship between flood and agriculture

Important results on relationship between agriculture and flood are as follows:

1) The Chane – Pailon Area

All crop yields during summer season in 1998 were much lower than those of the department because flood was very severe, the average depth was 74 cm and average duration was 20 days.

Ratio of harvested area per planted area was very low, soybean 36 %, rice 68 % and maize 18 %. This means that the flood damage for the crops is huge in the area.

2) The San Juan – Antofagasta Area

Rice yield, main crop in summer, in the area is higher than that of the departmental average, 2.9 and 2.3 t/ha respectively. Soybean yield, however, is lower, 1.3 and 1.8 t/ha. Especially, in the San Juan area, characterizing less severe flood area (average depth 30 cm and duration 4 days), rice yield records much higher than that of the department, 3.3 t/ha and 2.3 t/ha respectively.

(2) Irrigation

Rainfed cultivation is dominant in the both areas. The reasons why most of farmer does not apply irrigation, may be as follows:

- Large farm land per family,
- Insufficient water resources and no reservoir,
- Unsuited water quality for irrigation because of high salt content.

However, many farmers want to apply irrigation to their farm lands, 65 % of the farmers interviewed in the Chane-Pailon area and 87 % in the San Juan - Antofagasta area.

(3) Supporting Services

The distribution rate of technical extension services is low, especially the Chane-Pailon area is very low, only 15 % of the farmers receives the services. Generally, sources of the services are different by the scales of farm management, the large scale farmers receive from the farmer's cooperations such as CAICO and CAICY, the medium scale farmers from the producer's organizations and the small scale farmers from the NGO such as CIPCA (Centro de Investigacion y Promocion del Campesino).

(4) Low application ratio of agriculture inputs.

The application ratio of improved seeds, fertilizer and chemicals is low and the small scale farmers applied the inputs less than those of the large scale farmers. This may be the one reason for low yielding of the small farmers and may be caused by insufficient extension services.

(5) Low ratio of organized farmers

The ratio of organized farmers, belonging to the farmer's organization, is about 50 % in average. It is very important for farmers to belong to the farmer's organization in order to get an appropriate technology for avoiding or alleviation of flood risks.

5.5 Recommendations

Alleviation of flood damage is essential to sustain economic development not only the regional but also the national economy, as shown in Chapter 5.1, through stabilization of agricultural products in the study area.

According to the results of the farm interview survey there is much potentials to alleviate the flood damage by non-structural measures as follow.

(1) Cultivation of appropriate crops in accordance with soil and flood conditions, such as from non-water tolerant crops to water tolerant crops.

(2) Introduction of appropriate cropping calendars or farming systems by the flood conditions.

For example, it should be necessary to avoid any crop cultivation in the severe flood area during flood season because crops can not grow remuneratively in the area.

Land use zoning, which indicates appropriate land uses by land conditions, is prepared in the Study to show an idea of the non-structural measures. These measures are easier than the structural measures to implement. It is recommended that followings should be improved to expand these non-structural measures.

(1) To expand the agricultural technical extension services to the farmers, especially for small scale farmers.

(2) To organize the farmers for smooth implementation of extension services.

(3) To expand the agricultural research activities to the study on local agriculture, such as establishing an optimum crop calendar by area and introduction of appropriate crops and varieties.

(The CIAT implemented the trials if rice could grow after the flood season to avoid the flood damages. Though the flood situation by area is clarified in the Study, it is recommended that the CIAT should continue the trials for each flood condition to establish the appropriate cropping pattern and to introduce the appropriate crops and variety by zone)

TABLES

TABLE 5.1.1 MAIN AGRO-ECONOMIC INDEX

Item	Unit	1991	1992	1993	1994	1995
Whole Country						
GDP	Million Bs	16,256	16,524	17,230	18,034	18,877
Share of agricultural GDP*	%	16.0	15.1	15.1	15.4	14.9
Share of industrial crops	%	2.1	1.7	2.0	2.4	2.6
Share of nonindustrial crops	%	7.7	7.2	7.0	7.0	6.6
Livestock	%	4.2	4.2	4.2	4.2	4.0
Santa Cruz						
GRDP*	Million Bs	4,070	4,100	4,292	4,577	4,818
Ratio of the GRDP to the GDP	%	27	27	27	28	28
Ratio of the agricultural GRDP to the agricultural GDP	%	34	33	35	37	39
Share of agricultural sector in GRDP	%	22	20	21	23	23
Share of industrial crops in GRDP	%	7.4	6.1	7.2	8.7	9.3
Share of nonindustrial crops in GRDP	%	7.4	7.5	7.1	7.5	7.3
Share of livestock in GRDP	%	5.0	5.0	4.9	4.8	4.6
Share of crop in crop production						
Crop production	Million US $	283	296	349	411	512
Soybean	%	16	25	32	32	31
Rice	%	19	8	7	7	13
Maize	%	9	11	8	7	9
Sugarcane	%	20	12	10	8	8
Sorghum	%	2	3	1	3	4
Wheat	%	3	6	2	3	2
Sun Flower	%	1	1	1	2	1

* : 1990 Constant Price

Source : Numeros de Nuestra Tierra 1998

TABLE 5.1.2 MAIN CROP PRODUCTION AND THE SHARE IN THE DEPARTMENT

		93/94	94/95	95/96	96/97	97/98
Soybean	Ha	307,231	419,000	453,720	511,352	573,000
Santa Cruz	T/Ha	2.25	2.04	1.87	1.99	1.83
	TM	690,747	852,930	847,629	1,018,950	1,049,400
Study Area	Ha	58,598	74,300	60,550	59,152	61,500
	T/Ha	2.25	1.81	1.89	2.02	2.02
	TM	131,877	134,720	114,275	119,552	124,000
Share						
Planted Area	%	19.1	17.7	13.3	11.6	10.7
Yield	%	100	89	101	101	110
Production	%	19.1	15.8	13.5	11.7	11.8
Rice						
Santa Cruz	Ha	96,500	87,850	87,650	81,000	99,977
	T/Ha	2.00	2.38	3.22	2.33	2.32
	TM	193,000	208,650	282,642	188,904	231,539
Study Area	Ha	28,000	29,850	33,000	30,600	37,500
	T/Ha		2.34	3.34	2.64	2.64
	TM		69,800	110,213	80,752	99,100
Share						
Planted Area	%	29	34	38	38	38
Yield	%		98	104	113	114
Production	%		33	39	43	43
Wheat						
Santa Cruz	Ha	35,115	53,550	53,000	73,860	112,250
	T/Ha	0.95	1.40	0.73	1.36	1.07
	TM	33,360	74,970	38,500	100,669	120,414
Study Area	Ha	4,600	9,500	14,800	19,010	29,100
	T/Ha	1.80	1.95	1.50	1.90	1.69
	TM	8,280	18,525	22,200	36,119	49,241
Share						
Planted Area	%	13	18	28	26	26
Yield	%	189	139	206	139	158
Production	%	25	25	58	36	41
Maize						
Santa Cruz	Ha	85,600	89,000	98,700	100,000	66,350
	T/Ha	3.18	3.06	3.12	3.60	2.83
	TM	271,950	272,000	307,800	359,960	187,771
Study Area	Ha	3,000	10,000	11,500	13,800	7,500
	T/Ha	3.13	3.78	3.28	4.09	3.17
	TM	9,400	37,750	37,700	56,500	23,760
Share						
Planted Area	%	4	11	12	14	11
Yield	%	99	124	105	114	112
Production	%	3	14	12	16	13

Study Area: Total of areas corresponding the study area
Source: Numeros de Nuestra Tierr 1998

TABLE 5.1.3 EXISTING LAND USE IN 1997(OKINAWA)

Area	Unit	Upland	Fruits	Grazing Land	Reforestation Area	Uncleared Land	Others	Total
Okinawa 1	Ha	24,126	23	911	1	4,078	551	29,690
	%	81	0	3	0	14	2	100
Okinawa 2	Ha	7,390	6	2,814	140	969	231	11,550
	%	64	0	24	1	8	2	100
Study Area	Ha	31,516	29	3,725	141	5,047	782	41,240
	%	76	0	9	0	12	2	100

Source : JICA

TABLE 5.1.4 CHANGE OF PLANTED AREA BY CROP IN OKINAWA

		92	93	94	95	96
Soybean	%	73.2	75.5	60.8	54.3	53.0
Maize	%	5.0	4.0	3.4	5.6	4.4
Wheat	%	9.0	6.9	10.7	19.7	19.3
Rice	%	6.9	6.7	5.7	3.6	3.4
Sunflower	%	0.0	0.0	11.6	3.5	3.5
Sorghum	%	6.0	7.0	7.8	13.4	16.5
Planted area*	Ha	27,826	32,113	37,805	43,651	50,648

Source: CAICO *: Include Okinawa III

TABLE 5.1.5 CROP PRODUCTION AND YIELD IN 1997(OKINAWA)

Area	Unit	Soybean	Rice	Wheat	Maize	Sorghum	Sunflower
Okinawa 1	T	37,608	820	17,398	13,452	2,822	1,682
	T/Ha	2.0	2.0	1.6	3.2	2.4	1.3
Okinawa 2	T	9,458	0	3,654	3,649	1,825	632
	T/Ha	1.7	-	1.5	3.5	2.5	1.3
Study Area	T	47,066	820	21,052	17,101	4,647	2,314
	T/ha	2.0	2.0	1.6	3.2	2.4	1.3

Source : JICA

TABLE 5.1.6 NUMBER OF LIVESTOCK IN 1997(OKINAWA)

	Unit	Cow	Swine	Chicken
Okinawa 1	Head	4,342	2,425	8,000
	%	52	81	42
Okinawa 2	Head	3,989	576	11,050
	%	48	19	58
Study Area	Head	8,331	3,001	19,050
	%	100	100	100

Source : JICA

TABLE 5.1.7 RESULTS OF INTERVIEW SURVEY FOR FARMERS IN THE CHANE-PAILON AREA EXCEPT OKINAWA

(1) Land Use

Land Tenure	Unit	Annual crop	Perennial crop	Grazing	Others	Total
20 Ha >	%	79	1	2	18	100
21 – 100 Ha	%	45	9	14	32	100
Average	%	56	7	10	28	100

(2) Crop Production

		Soybean	Rice	Maize	Others	Total
Ratio of Planted Area in Summer Season						
20 Ha >	%	32	39	28	1	100
21 – 100 Ha	%	46	50	4	0	100
Average	%	40	45	14	0	100
Crop Yield in Summer Season						
20 Ha >	T/Ha	0.0	0.4	1.2	-	-
21 – 100 Ha	T/Ha	1.6	0.7	0.2	-	-
Average	T/Ha	1.1	0.6	1.0	-	-
Ratio of Harvested Area per Seeded Area in Summer Season						
20 Ha >	%	50.0	44.9	27.3	-	-
21 – 100 Ha	%	87.1	79.1	9.1	-	-
Average	%	74.5	66.5	24.2	-	-

(3) Number of Livestock Raising per Family

		20 Ha >	21-100Ha	Average
Caw	Head	1.0	3.1	1.4
Swine	Head	0.7	1.8	1.0
Chicken	Head	3.3	8.8	4.6

Source: Study Team

TABLE 5.1.8 EXSE IN 1997(SAN JUAN)

	Unit	Upland	Fruits	Grazing Land	Reforestation Area	Uncleared Land	Others	Total
Area	Ha	19,266	1,291	3,487	8	6,528	570	31,145
Share	%	62	4	11	0	21	2	100

Source : JICA

TABLE 5.1.9 MAIN CROP PRODUCTION IN SAN JUAN

		93/94	94/95	95/96	96/97	97/98*
Soybean (Summer)	Ha	2,050	1,980	1,960	1,416	
(Winter)	Ha	7,150	7,350	9,274	8,182	
Total	Ha	9,200	9,330	11,234	9,598	10,012
	T/Ha	1.8	1.7	1.7	2.0	1.9
	T	16,181	15,686	18,557	19,591	19,068
Rice	Ha	7,350	8,559	9,868	8,112	10,244
	T/Ha	2.8	3.1	3.3	3.4	3.1
	T	20,410	26,420	33,014	27,670	31,977
No. of chicken	Head	590,000	626,000	690,000	719,000	917,110
Egg production	1,000	160,778	177,123	189,972	203,342	197,903
No. of caw	Head	1,950	1,957	2,024	2,057	4,621

Source:CAISY *: JICA

TABLE 5.1.10 RESULTS OF INTERVIEW SURVEY FOR FARMERS IN ANTOFAGASTA

(1) Land Use

Land Tenure	Unit	Upland crop	Perennial crop	Grazing	Others	Total
20 Ha >	%	85	0	0	15	100
21 – 100 Ha	%	82	0	2	16	100
Average	%	83	0	2	15	100

(2) Crop Production

		Soybean	Rice	Total
Ratio of Planted Area in Summer Season				
20 Ha >	%	15	85	100
21 – 100 Ha	%	49	51	100
Average	%	44	56	100
Crop Yield in Summer Season				
20 Ha >	T/Ha	1.0	1.5	
21 – 100 Ha	T/Ha	0.6	2.0	
Average	T/Ha	0.7	1.9	
Ratio of Harvested Area per Planted Area in Summer Season				
20 Ha >	%	67	84	
21 – 100 Ha	%	51	81	
Average	%	52	82	

(3) Number of Livestock Raising per Family

		20 Ha >	21-100Ha	Average
Caw	Head	1.5	2.1	1.9
Swine	Head	0.1	4.4	2.6
Chicken	Head	1.0	8.9	4.7

Source: Study Team

TABLE 5.2.1 EXISTING LAND USE(1998)

	Unit	Upland field	Other* crop field	Grazing land	Primary forest	Secondary forest	Urban area	Lake & river	Total
Chane -	Km^2	336.9	94.4	58.8	93.3	13.4	2.6	0.3	599.3
Pailon Area	%	56.2	15.7	9.8	15.6	2.2	0.4	0.0	100.0
San Juan -	Km^2	407.9	10.8	64.5	70.9	51.6	1.7	0.0	607.3
Antofagasta Area	%	67.2	1.8	10.6	11.7	8.5	0.3	0.0	100.0

*: Sugarcane field in the Chane - Pailon Area and Fruits field in the San Juan - Antofagasta area
Source: Study Team

TABLE 5.2.2 LAND CLASSIFICATION BY SUB-AREA

Unit: Km^2

	Chane-Pailon Area				San Juan-Antofagasta Area			
Legend	Chane	Pailon	Okinawa	Total	San Juan	Antofagasta	Total	Limitation*
II-02	29.3	43.1	83.2	155.7	0.0	0.0	0.0	T,N
III-01	0.0	53.8	33.9	87.7	5.7	78.6	84.3	N,DI
III-06	14.6	99.4	0.0	114.0	0.0	0.0	0.0	N
III-07	0.0	0.0	0.0	0.0	63.6	74.0	137.6	DI
IV-07	0.0	11.9	0.0	11.9	0.0	0.0	0.0	N,CA
IV-08	19.3	0.0	0.0	19.3	240.5	45.2	285.7	DI
V-02	44.2	59.3	52.8	156.4	0.0	0.0	0.0	DI,IN
V-05	14.7	0.3	8.0	23.0	0.0	0.0	0.0	DE,DI,N,IN
V-09	17.5	3.1	0.0	20.6	0.0	0.0	0.0	DI,CI,P
V-10	0.0	0.0	0.0	0.0	30.6	0.0	30.6	DI,N,X,CA,IN
V-11	0.0	0.0	0.0	0.0	28.9	28.3	57.2	DI,S,X
V-17	0.0	0.0	0.0	0.0	0.0	12.0	12.0	DE,DI,X
VI-05	0.0	0.0	7.1	7.1	0.0	0.0	0.0	DI,IN
VII-05	4.0	0.0	0.0	4.0	0.0	0.0	0.0	DE,N,CA,IN
	143.7	270.9	185.0	599.6	369.3	238.0	607.3	

*: T: Topography, N: Nutrition, DE: External Drainage, DI: Internal Drainage, CA: Water Capacity, IN: Inundation, CI: Hardness, P: Soil Depth, X: Toxic Substance, S: Salt
Source: Departmental Office

TABLE 5.2.3 SUMMARY OF LAND CLASSIFICATION

Area	Class	II	III	IV	V	VI	VII	Total
Chane-Pailon	Km2	155.7	201.7	31.2	400.0	7.1	4.0	599.6
	%	26.0	33.6	5.2	66.7	1.2	0.7	100.0
San Juan-	Km2	0.0	221.9	285.7	99.8	0.0	0.0	607.3
Antofagasta	%	0.0	36.5	47.0	16.4	0.0	0.0	100.0

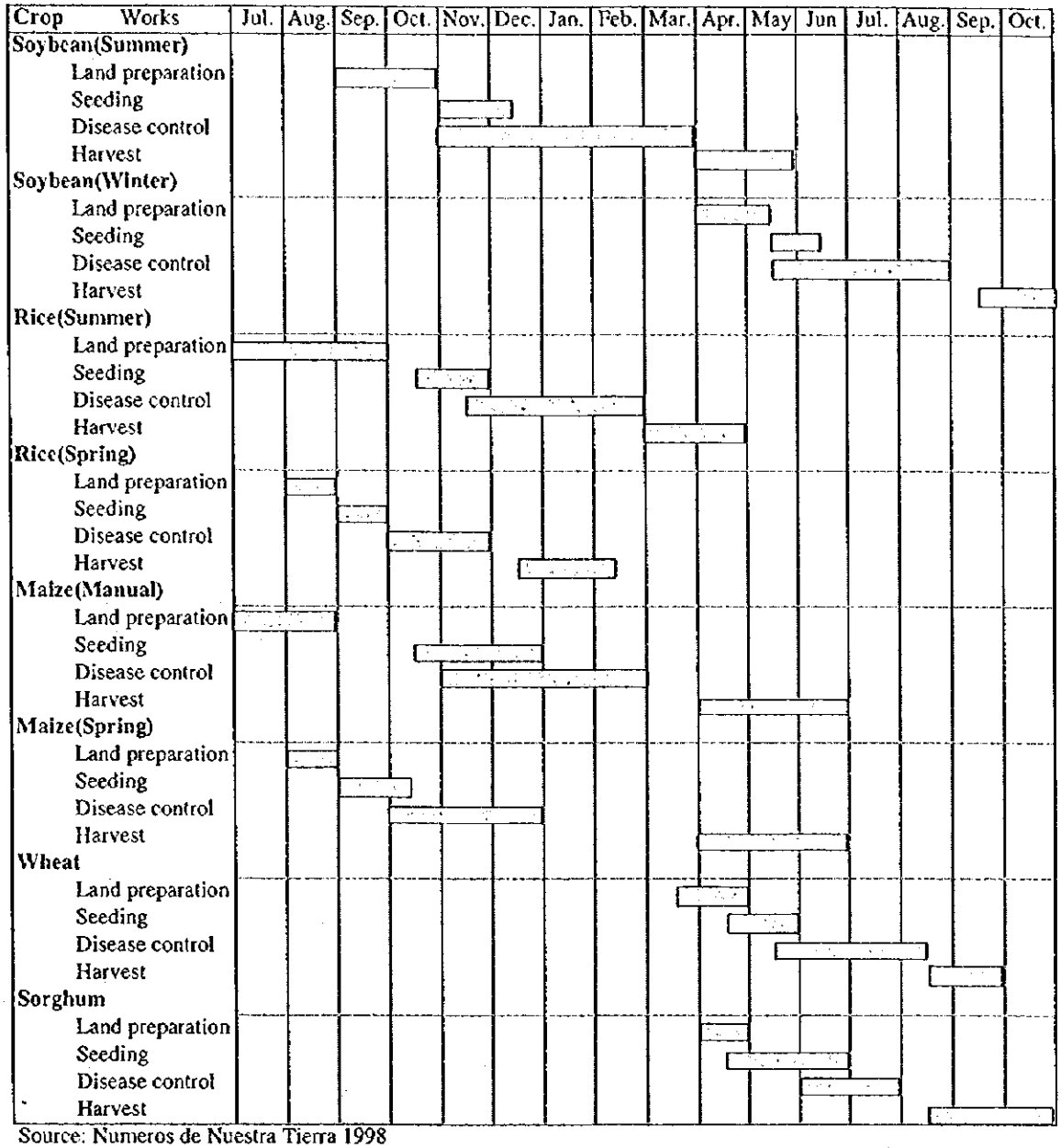
Source: Departmental Office

TABLE 5.3.1 ZONING CATEGORY AND RECOMMENDED LAND USE

Zone	Flood Depth	Soil Classification	Existing Land Use	Recommended Land Use	
				Summer(Flood season)	Winter
1	No flood	II-02,III-01, 06,07,IV08	Upland crop,	Any crops	Any crops
2	50 cm >	II-02,III-01, 06,07,IV08	Upland crop, Sugar cane ,Forest,	Water tolerant crops such as rice	Any crops
3	50 cm <	II-02,III-01, 06,07,IV08	Upland crop, Sugar cane, Grazing land	Crop rotation keeping away from flood season	Any crops
4	No flood	IV-07	Grazing land, Upland crop	Perennial crop, Grazing land	Perennial crop, Grazing land
5	50 cm >	IV-07	Grazing, Forest, Upland crop	Grazing land	Grazing land
6	-	V-02,V-10,11,17, VI-09,05, VII-05	Forest, Grazing, Sugar cane	Grazing land, Forest	Grazing land, Forest

Source: Study Team

FIGURES



Source: Numeros de Nuestra Tierra 1998

FIG.5.1.1 REPRESENTATIVE CROPPING CALENDAR

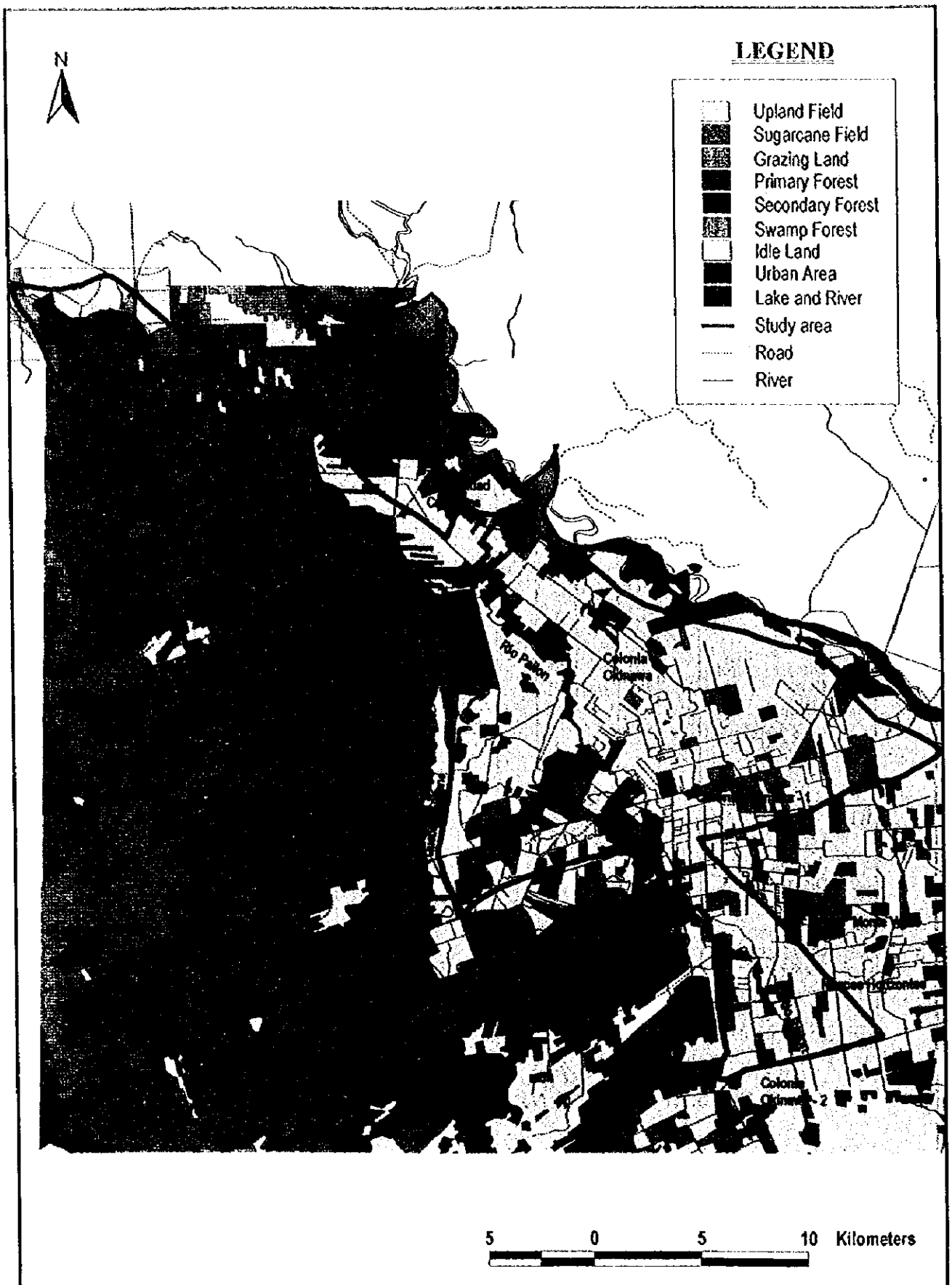


FIG.5.2.1(1) LAND USE MAP IN 1998
(Chane - Pailon Area)

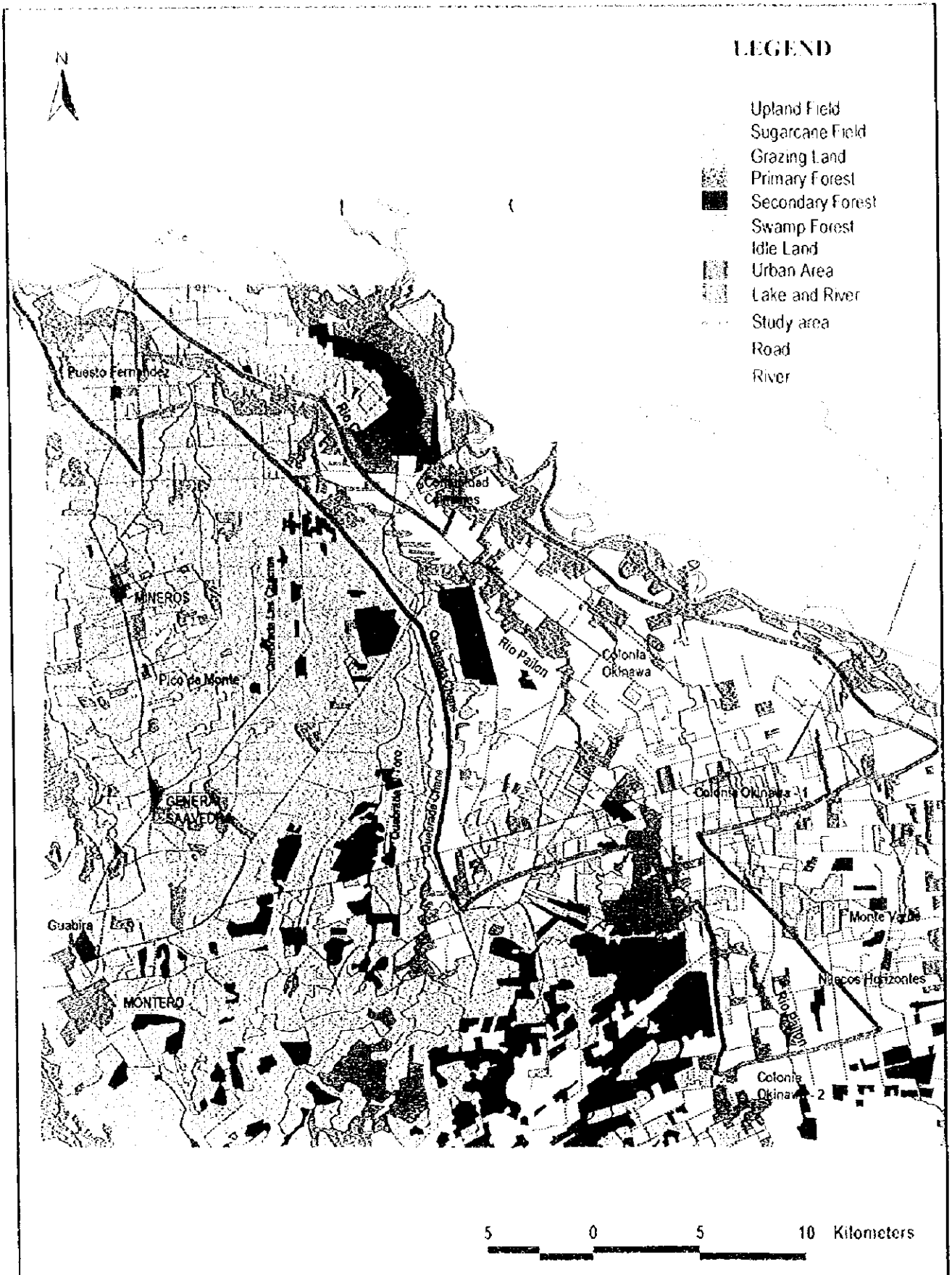


FIG.5.2.1(1) LAND USE MAP IN 1998
(Chane - Pailon Area)

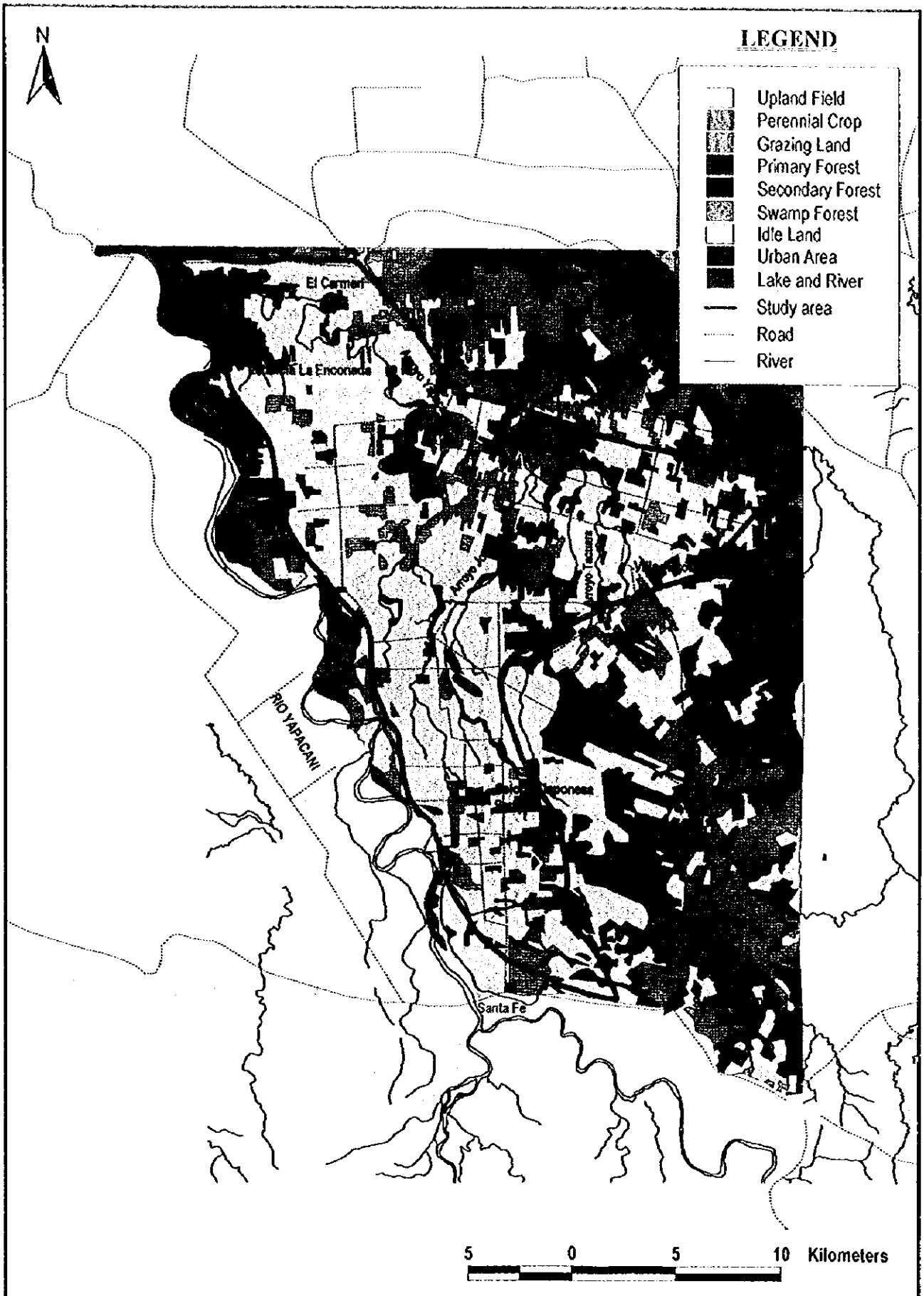


FIG.5.2.1(2) LAND USE MAP IN 1998 (SAN JUAN - ANTOFAGASTA AREA)

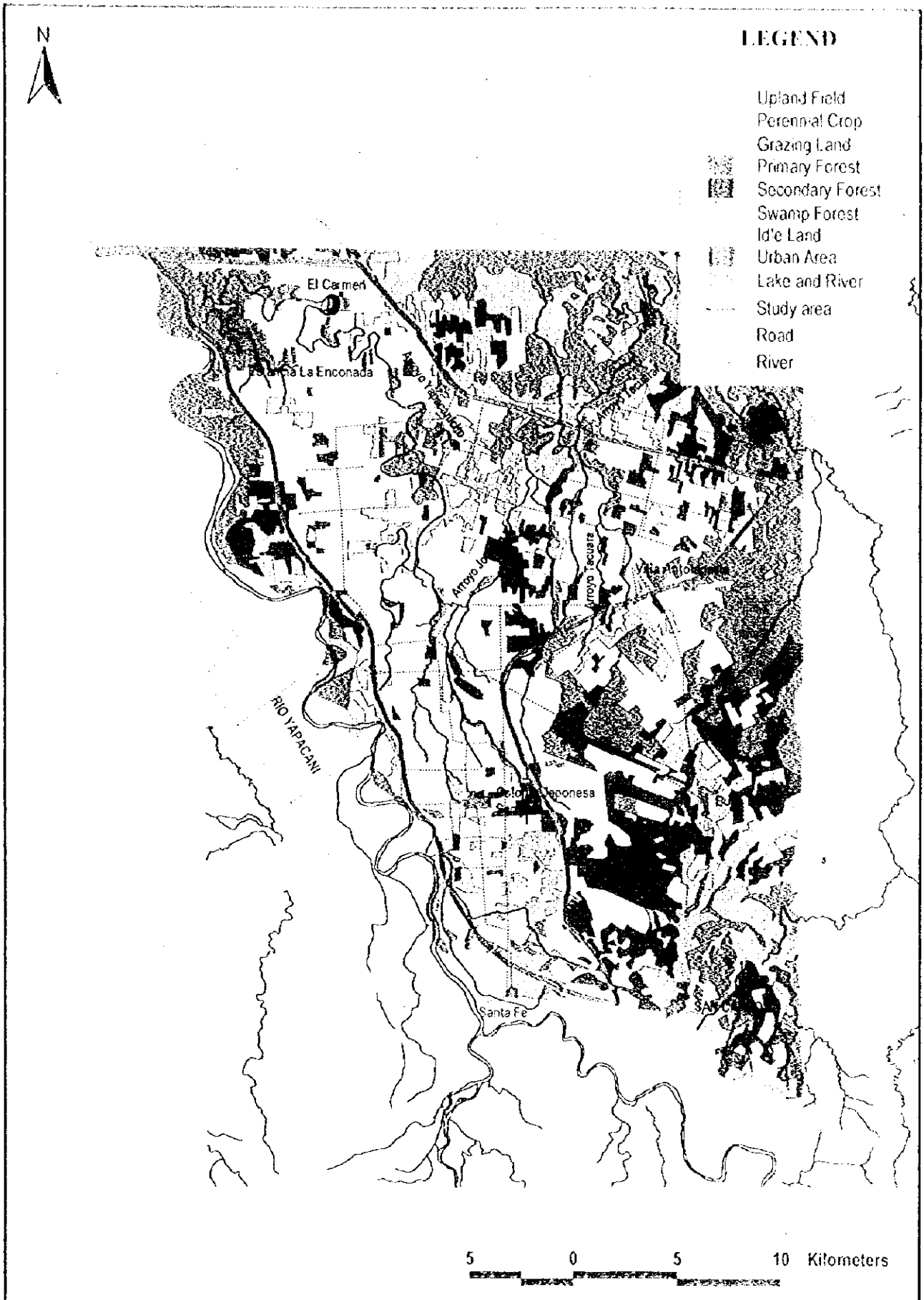


FIG.5.2.1(2) LAND USE MAP IN 1998 (SAN JUAN - ANTOFAGASTA AREA)

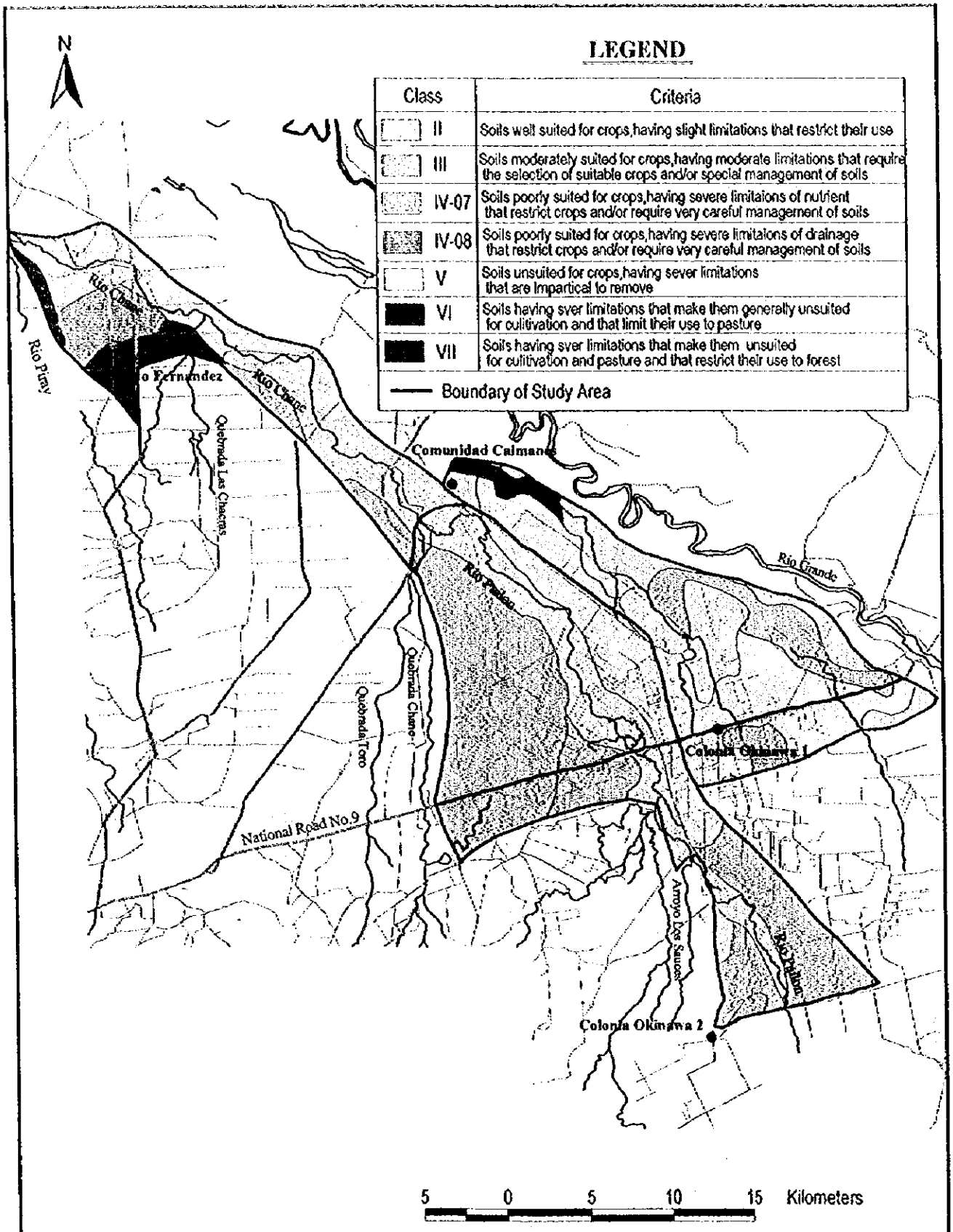


FIG.5.2.2 (1) LAND CLASSIFICATION MAP (Chane -Pailon Area)

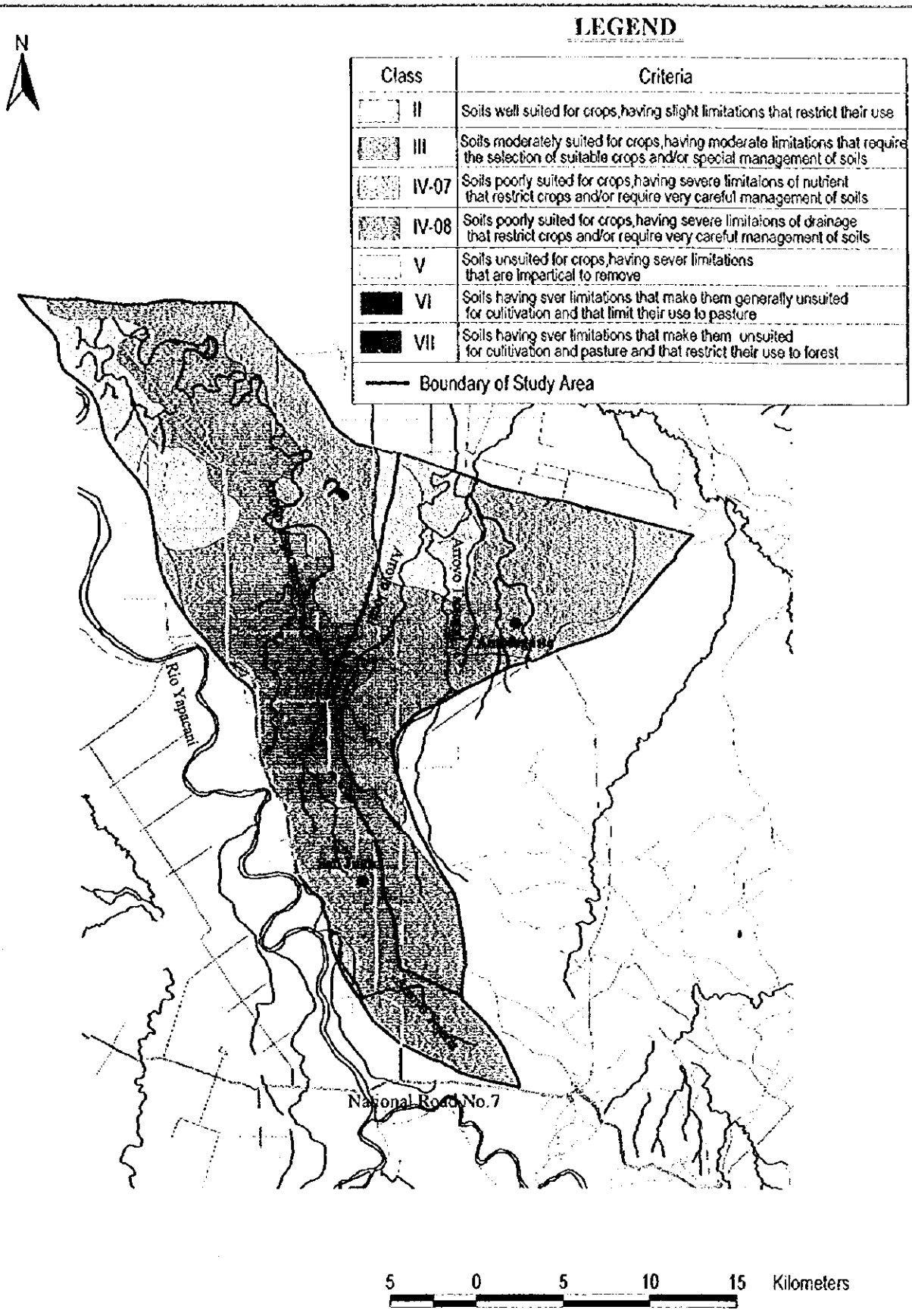


FIG.5.2.2 (2) LAND CLASSIFICATION MAP (Sun Juan - Antofagasta Area)

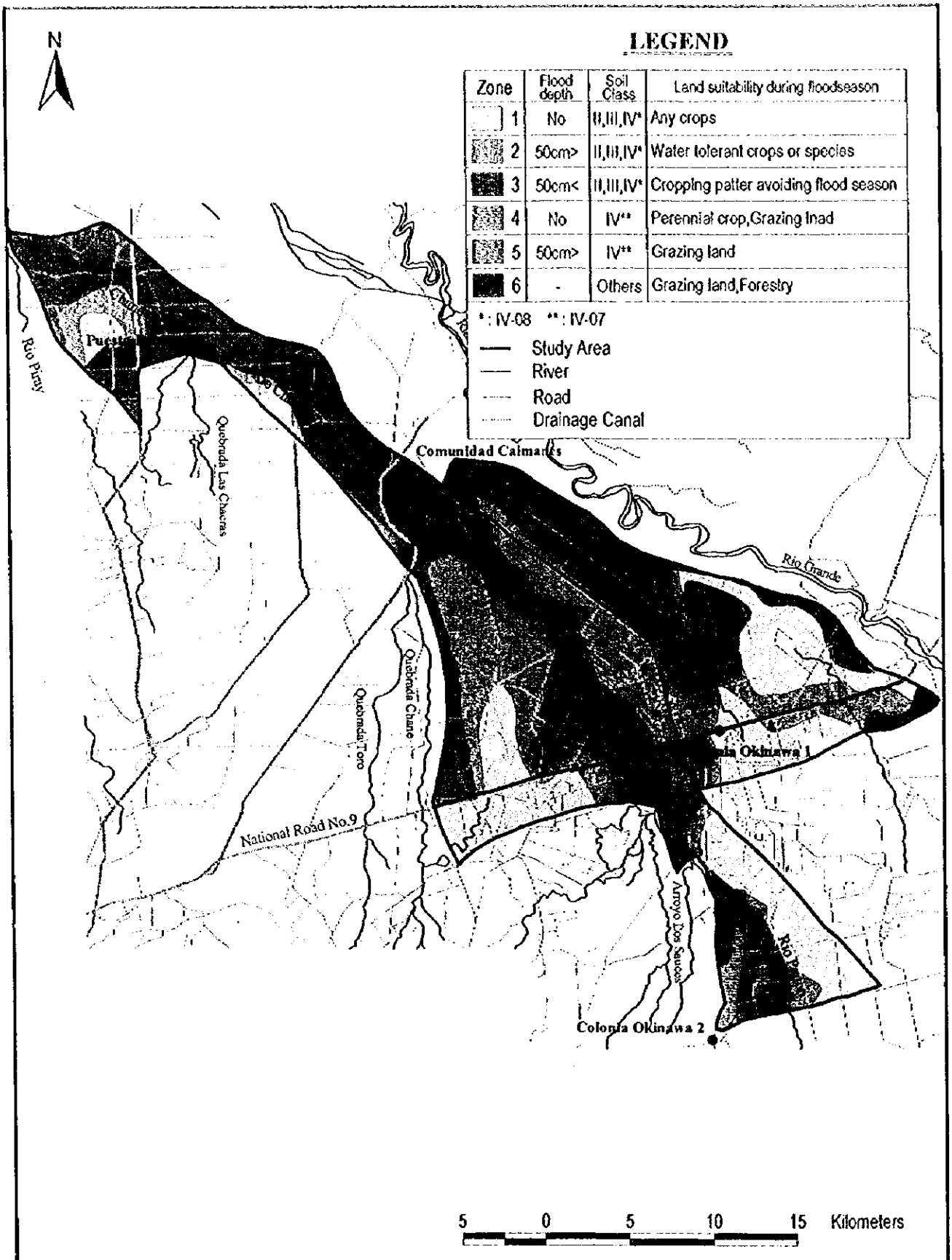


FIG.5.3.1 (1) ZONING FOR AGRICULTURAL LAND USE IN CHANE-PAILON AREA (Flood area during November 97 to March 98)

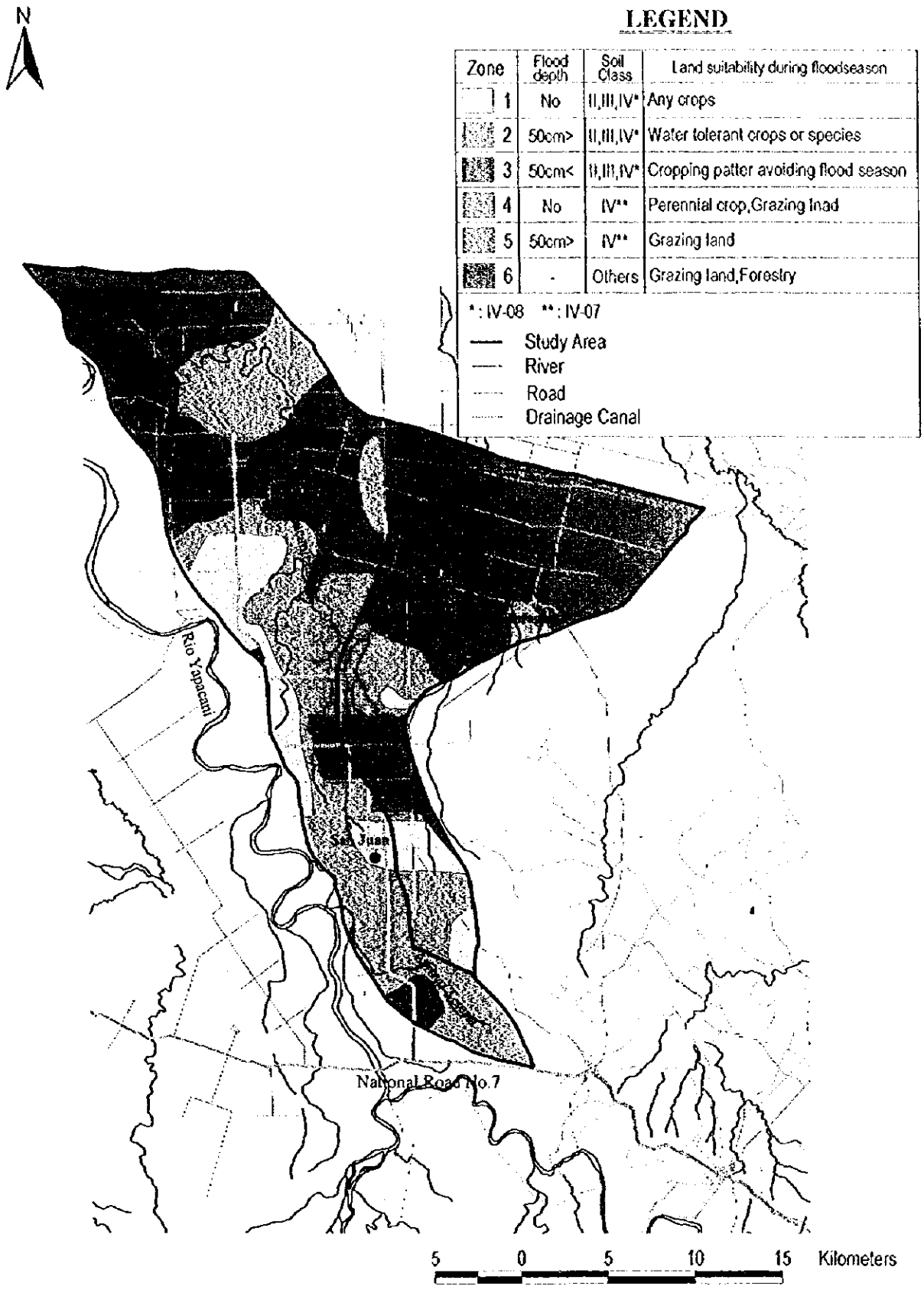


FIG.5.3.1 (2) ZONING FOR AGRICULTURAL LAND USE IN SAN JUAN-ANTOFAGASTA AREA (Flood area during December 96 to February 97)

CHAPTER 6

FLOOD MITIGATION AND DRAINAGE IMPROVEMENT

CHAPTER 6 FLOOD MITIGATION AND DRAINAGE IMPROVEMENT

6.1 Flood Mitigation

6.1.1 Basic Concept of Flood Mitigation

(1) General Condition of Flood

The Study Area is located in the flood hazard area, which is classified by the cause of floods into the following four categories:

Category	Causes of Floods
-1	Inundation area caused by floods from the major river such as the Rio Grande, Rio Piray, or Rio Yapacani,
-2	Inundation area caused by floods from its own basin with the backwater effect of the Rio Piray,
-3	Inundation area caused by floods from its own basin with floods from the major river,
-4	Inundation area caused by floods from its own basin.

The Study Area was divided as follows:

1) The Chane - Pailon Area

In the Rio Pailon Basin, the downstream area of the National Road No. 9 belongs to the Category -2. The area is suffered from the annual floods and severely damaged by the 1992 floods.

The upstream area of the National Road No. 9 belongs to the Category -4. The flood damages are not so severe as in the downstream area because the depth and duration of floods are less than those in the downstream area.

The lower reach of the Rio Chane belongs to the Category -1 and -2. The flood conditions of the reach need to be improved partly by the flood mitigation measures of the Rio Piray.

The Okinawa Drainage basin belongs to the Category -1 and -4. The area is suffered from floods mainly caused by its own basin, however, sometimes floods from the Rio Grande have the influence as well.

The areas between the Rio Grande and the Rio Chane – Pailon are flooded by the Rio Grande. These areas are classified into the Category –1 and –2 in the downstream of the highway no. 9 and the Category –1 and –4 in the upstream of the highway no. 9 between the courses of these rivers.

2) The San Juan – Antofagasta Area

This area belongs to the Category -3 and -4. This area consists of the Arroyo Yapacanicito, Arroyo Jochi and Arroyo Tacuaral basins. The Colonia San Juan de Yapacani is an intensive agricultural area of rice, egg and soybean. Antofagasta is an important local colony with high agricultural potential.

(2) Basic Concept for the Flood Mitigation Measures

Flood mitigation measures are composed of the structural and non-structural measures. The structural measures are planned to apply for the area that has severe flood damages and the non-structural measures are planned for the area that has no significant flood problems in the Master Plan Study in 1996. According to the flood survey and analysis, the Study Area is recognized as a severe flood damage area, therefore both structural and non-structural measures will be applied comprehensively.

The structural measures proposed in the Master Plan Study in 1996 were as follows:

- River improvement
  The river improvement work is to increase the conveyance capacities of channels by widening, deepening and improving the channels.

- Road-cum-embankment
  The road-cum-embankment is to have the function of both flood embankment and roads.

As the flood hazard area is mainly composed of agricultural lands, the complete mitigation of flood and drainage problems is unlikely feasible physically and economically. Therefore, the reduction of the required scale of the flood mitigation and drainage improvement facilities is needed. In order to reduce the

required scale, the effective use of the natural retarding basin of the marshy area etc. was proposed in the Master Plan Study in 1996.

(3) Review of the Structural Measures Proposed in the Master Plan Study

1) The Chane – Pailon Area

The area consists of 6 drainage basins as follows:

- The Rio Chane basin,
- The Rio Pailon basin,
- The Quebrada Chane basin,
- The Quebrada El Toro basin,
- The Quebrada Las Chacras basin,
- The Okinawa Drainage basin.

The structural measure proposed was the river improvement, mainly by enlarging the existing river cross-sections to increase their flow capacities.

In the Master Plan Study, a priority order was set up for the basin from technical, economic, social and environmental aspects. The proposed priority basins for the Feasibility Study were identified as follows:

- Rio Chane basin,
- Rio Pailon basin,
- Okinawa Drainage basin.

2) The San Juan – Antofagasta area

The areas identified in the Master Plan Study were as follows:

- The San Juan area,
- The Antofagasta area.

The structural measures proposed were the river improvement and the road-cum embankment. The river improvement was mainly by enlarging the existing river cross-sections to increase their flow capacities while the road-cum embankment was to increase the height of the embankment to protect the overflow.

In the Master Plan Study, a priority order was also set up for the area from technical, economic, social and environmental aspects. The proposed priority areas for the feasibility study were as follows:

- The San Juan Area,
- The Antofagasta Area.

6.1.2 Design Scale and Criteria

(1) Design Scale

The design scales for river improvement based on the results of the analysis in technical, economical and social aspects in the Master Plan Study, are as follows:

1) The result of the analysis in the Chane - Pailon Area shows that the most effective design scale for the flood mitigation is between 5-year and 10-year flood frequencies.

2) The result of the analysis in the San Juan - Antofagasta Area shows that the most effective design scale is about 10-year flood frequency.

Accordingly the design scale of a 10-year frequency flood is decided to apply for the river improvement works in the Feasibility Study.

(2) Design Criteria

Design criteria for the structural measures set up in the Master Plan Study are also used in the Study. The criteria are summarized as follows:

1) Design flood scale

The design flood scale was decided from the hydrological analysis as follows:

The flood mitigation facilities: 10-year return period.

2) Allowable inundation depth

The allowable inundation depth decided by considering the tolerance and damages of the crops in the study area is:

Allowable inundation depth : 30 cm

3) Design cross sections

The design cross section for the flood mitigation, which was decided by the concept to allow inundation in the flood plains along the river during the design flood, is a single trapezoidal section.

6.1.3 Proposed Structural Measures for Flood Mitigation

(1) River Improvement

The proposed river improvement works are:

1) The Chane -- Pailon Area
   - Rio Chane (length: 26.350 km)
   - Rio Pailon (length: 31.410 km)

2) The San Juan – Antofagasta Area
   - Arroyo Yapacanicito (length: 17.360 km)
   - Arroyo Jochi (length: 11.800 km)
   - Arroyo Tacuaral (length: 5.800 km)

Location of the proposed structural measures is shown in Fig. 6.1.1.

The project items and design cross section of the river improvement works are shown in Table 6.1.1. The design cross sections and longitudinal profiles are decided based on the results of the hydrodynamic analyses mentioned in the Chapter 4. The design discharges are shown in Fig. 6.1.2. The proposed river bed elevations are set to minimized the excavation works under the condition that the 5-year frequency flood will run off without overflow and 10-year frequency flood will run off with allowable inundation depth of 30 cm. The proposed longitudinal profiles for the river improvement works are shown in Fig. 6.1.3.

(2) Related Structures

1) Road-cum-embankment

The road-cum-embankment is planned to apply in the San Juan – Antofagasta area. The proposed road-cum-embankment is from the San Juan Main Road to the Antofagasta Main Road along the boundary of the Arroyo Yapacanicito and Arroyo Jochi basins with a total length of 9.83 km. It is to separate the two river basins physically and prevent the floodwater to flow over from the Arroyo Jochi basin to the Arroyo Yapacanicito basin.

The elevation of the road-cum-embankment is in principle set at 80 cm from the ground level or higher, by considering a 30 cm allowable inundation depth at the 10-year frequency flood in addition to a 50 cm free board depth. The proposed profile of the road-cum-embankment is shown in Fig. 6.1.4.

2) Bridge

Due to the channel widening, some of the existing bridges along the rivers in the improvement range are to be replaced by new ones. A total of nine (9) bridges is planned to be replaced as follows:

The Chane – Pailon Area

- Rio Chane : 4 bridges
- Rio Pailon : 1 bridge

The San Juan Antofagasta Area

- Arroyo Yapacanicito : 1 bridge
- Arroyo Jochi : 2 bridges
- Arroyo Tacuaral : 1 bridge

The design criteria for the bridges are summarized as follows:

- Design Flood Scale
  A 50-year frequency flood is applied for the design flood condition of bridges in consideration with the importance of the structures.

- Bridge Width
  The proposed bridges are categorized into 2 types based on the existing road condition and expected traffic volume. The Type-A bridge, 8 m wide, will be applied for the heavy traffic condition and the Type-B bridge, 5.5 m wide, for the light traffic condition.

The location and dimension of the proposed bridges are listed in Table 6.1.2.

6.1.4 Inundation Area

Due to the river and drainage improvement works, the Study Area will be significantly improved in both of inundation area and inundation depth. However, some of the inundation area will be remained.

The inundation areas under the conditions of with and without the project in several flood frequencies are studied based on the HD simulation as mentioned in Chapter 4. The estimated inundation area and depth with and without project in the 10-year frequency flood are shown in Table 6.1.3 and Figs. 6.1.5 and 6.1.6. The areas are summarized below:

INUNDATION AREA BY 10-YEAR FREQUENCY FLOOD

	The Chane - Pailon Area			The San Juan - Antofagasta Area	
	Rio Chane	Rio Pailon	Okinawa D.	San Juan	Antofagasta
Inundated area without project	91.8 %	90.4 %	59.8 %	91.5 %	97.3 %
Inundated area with project	88.8 %	29.6 %	13.4 %	58.3 %	45.6 %
Ratio of with / without	96.7 %	32.7 %	22.4 %	63.7 %	46.9 %

Along the Rio Chane, the reduction of inundation area is estimated to be small because this area is affected by the backwater from the Rio Piray and also the increase of discharge due to the improvement of upper reach. However, the average inundation depth will decrease by the project in this area. In the other basins, the inundation area will decrease by the project from 22.4 % to 46.9 % of the inundation area without project.

6.1.5 Bill of Quantity for Flood Mitigation

The bill of quantities of the river improvement works and the road-cum-embankment are shown in Table 6.1.4.

6.2 Drainage Improvement

6.2.1 Basic Concept of Drainage Improvement

(1) General Conditions of Drainage System

In general the drainage condition in the Study Area is not efficient due to its gentle and bumpy topographic and low permeability soil. The inundation occurs frequently by heavy rainfalls and floods from the rivers during the rainy season between November and February, for 4 months. The water tends to stagnate in a long duration as a result of the inefficient drainage condition. However, some heavy rainfalls with a short duration of about 1 or 2 days in the dry season sometimes also cause the inundation even in the dray season.

The poor drainage areas in the Study Area identified are shown in Fig. 6.2.1. The poor drainage areas due to the topographic and soil conditions are studied based on the land classification made by the UTD-PLUS of the Department. The poor drainage areas due to the insufficient capacity for the floods from the rivers are studied based on the results of the Master Plan Study and the questionnaire survey for the flood conditions conducted during the Study. The drainage condition in the Study Area is summarized as follows:

Drainage Area	Area in Total (km^2)	Area with Drainage Problem (Land Class II to IV) (km^2)	Area with Drainage Problem (Land Class V to VII) (km^2)	Area suffered by Annual Flood(km^2)
Chane Area	143.7	19.3	62.9	121.3
Pailon Area	270.9	53.8	59.7	122.2
Okinawa Drainage Area	185.0	33.9	67.8	162.1
San Juan Area	369.3	309.8	59.5	292.0
Antofagasta Area	238.0	197.8	40.2	134.7
TOTAL	1,206.9	614.6	290.1	832.1

(2) Basic Concept for Drainage Improvement

The basic concept for the drainage improvement in the Study Area is summarized as below:

1) The Chane Basin

This area will benefit from the improvement of the Rio Chane in the inundation condition significantly.

2) The Pailon Basin

This area will also benefit from the improvement of the Rio Pailon in the inundation condition significantly. The development of the secondary drainage system is also required to enhance the effect of the river improvement.

The northern area along the National Road No.9, between the Rio Pailon and the El Tajibo Village, has been suffering from the poor drainage conditions. In order to improve the situation, it is required to develop the drainage channels downstream the Route No. 9.

3) The Okinawa Drainage Basin

In the lower reach of the Route No. 9, a main drainage network along the existing drainage channels is proposed to improve and the drainage channel is to be extended up to the supposed former river course of the Rio Grande. The excess water is to be drained to the former river course of the Rio Grande.

The improvement of the Okinawa Drainage Main will contribute to the mitigation of the flood damages caused by the floods from the Rio Grande by conveying the external floodwater quickly.

4) The San Juan Area

The improvement of the flow capacity of the Arroyo Tejeria and Jochi, and the construction of a road-cum-embankment between the Arroyo Yapacanicito and Jochi basins are able to prevent the intrusion of the floodwater among these basins.

The improvement of the flow capacity of the Arroyo Yapacanicito, the rehabilitation of the existing drainage mains and the development of the secondary canal networks are necessary to increase the drainage capacity in the area.

5) The Antofagasta Area

The improvement of the drainage capacity in the area is to improve the Arroyo Jochi and Tacuaral, to construct a drainage main in the central area and to develop the secondary drainage networks.

It is also required that the swamp area is to be conserved as a retarding basin to reduce the impact of the improvement of the rivers and drainage system to the down stream basin.

6.2.2 Design Scale and Criteria

(1) Design Scale

The design scale for the drainage facility is planed to be from 2 to 5-year frequency, with no inundation depth at the 2-year flood frequency and with the allowable inundation depth at 5-year flood frequency.

(2) Design Criteria

1) Allowable Inundation Depth and Duration for Crop

For the drainage improvement plan, it is reasonable to consider an allowable inundation depth for crops. According to the Master Plan Study on the flood damages for crops, the allowable inundation depth is planned to be 30 cm.

2) Canal Classification

The planned drainage canal is classified by its role in the drainage system. The drainage main is specified as the primary drainage canal that drains directly to the river and the secondary drainage canal is the canal that drains to the drainage main.

6.2.3 Proposed Structure Measures for the Drainage Improvement

(1) Drainage Improvement

The proposed structural measures for the drainage improvement is composed of the improvement, development and rehabilitation of main drainage, development of secondary drainage and improvement of drainage channels for crossing the National Road No.9.

The proposed drainage improvement works are:

1) The Chane – Pailon Area

Main Drainage

- Okinawa Main Drainage (length: 21.650 km)

Drainage Channels for Crossing the National Road No.9

- El Rancha Chico (length: 3.600 km)
- El Chaco (length: 1.470 km)
- El Empalme II (length: 5.290 km)

Secondary Drainage
- Pailon Basin

2) The San Juan – Antofagasta Area

Main Drainage

- San Juan Main Drainage	(total length:	34.950 km)
- Arroyo Tejeria	(total length:	8.160 km)
- Antofagasta Main Drainage	(total length:	8.800 km)

Secondary Drainage
- San Juan Area
- Antofagasta Area

The project items and design discharge, design cross section of drainage improvement plan are shown in Table 6.2.1. The proposed cross sections of the drainage improvement are set under the conditions of the overflow. The internal runoff of the basin at the 2-year frequency flood will cause no overflow on the bank and the internal runoff of the basin at the 5-year frequency will cause a less than 30 cm depth of overflow on the bank. The proposed longitudinal profiles of the drainage improvement are shown in Fig. 6.2.2.

San Juan Main Drainage composes of 6 existing drainage channels, i.e., km 11, km 13, km 15, km 17, km 24 and km 28 drainage channels. The channel improvement works including the removal of drop works and the adjustment of longitudinal profile are proposed to the km 13 drainage and km 17 drainage channels. The rehabilitation works of channels composing of the repair of collapsed channel and the slope forming are proposed to the km 11, km 15, km 24 and km 28 drainage channels.

Secondary drainage canals are planned as follows:

- Each canal length	:	2-3 km long from drainage main or drainage river
- Drainage area	:	5.0 sq. km each
- Canal density	:	0.4 km/sq. km

The total length of drainage canal at each drainage area is estimated based on the case study in the Master Plan Study.

$$L\ km = A_{BASIN}\ km^2 \times 0.40\ km/km^2 \times 0.75$$

whereby,

L: Canal Volume of Length (km)

A_{BASIN}: Area of Basin (km^2)

The secondary drainage network development is planned based on above condition and topographic conditions. The proposed secondary drainage improvement is shown in Table 6.2.2.

(2) Related Structures

1) Bridge

Due to the channel widening, some of existing bridges along the proposed drainage improvement will be renovated. Seven (7) bridges are proposed to reconstruct for the drainage improvement, which is summarized as follows:

The Chane - Pailon Area

- Rio Pailon Basin 1 bridge
- Okinawa Drainage Basin 1 bridge

The San Juan - Antofagasta Area

- San Juan Area 3 bridges
- Antofagasta Area 2 bridges

The dimension criteria for the bridge construction are same as the bridge in the river improvement works.

2) Culvert

During the secondary drainage network development, culverts are necessary to be constructed. The location and dimension of proposed bridge and culvert reconstruction are listed in Table 6.2.3.

6.2.4 Bill of Quantity for the Drainage Improvement

The bill of quantities for the drainage improvement works is shown in Table 6.2.4.

6.3 Operation and Maintenance

The operation and maintenance works for the river and drainage improvement consist of inspection, regular maintenance, periodic maintenance and rehabilitation works. They are defined as a systematic activity in order to preserve and maintain the river and

drainage systems under an acceptable condition. The work plan for the operation and maintenance work is shown below:

Items	Activities	Recommended Frequency
Inspection	To identify the channel condition of rivers/drainage.	Around once a month
Regular Maintenance	Mowing and partial repair of channel side slopes to keep the flow capacity of the channel in the minimum requirement.	Before and after the flood season yearly
Periodic Maintenance	Repairing collapsed channel slopes and dredging channel bed to recover the flow capacity nearly to the initial condition.	Depends on the damage (around once a few years)
Rehabilitation	Large scale repair and rehabilitation of channels.	Depends on the damage

The operation and management works for river and drainage are classified into 2 categories due to the scale of target systems, i.e., river and drainage systems. The river management should be conducted under the initiative of the Department Government because river basins cover more than one Municipality and the operation and maintenance works for rivers are large scale in general. On the other hands, an individual local government (municipality level) due to the basin and work scale can conduct the drainage management. The division of operation and maintenance activities is proposed as below:

Items	River Management	Drainage Management	
		Main Drainage	Secondary Drainage
Responsible Organization	Department Government	Municipality	Inhabitants group
Inspection	Municipality under the control of Department Government	Municipality with inhabitants participation	Inhabitants group
Regular Maintenance	Municipality with inhabitants participation under the control of Department Government	Municipality with inhabitants participation	Inhabitants group
Periodic Maintenance	Department Government	Municipality	Inhabitants group
Rehabilitation	Department Government	Municipality	Inhabitants group

6.4 Non-structural Measures

Non-structural measures are planned to apply for the whole potential flood hazard area. The structural measures generally require a long period before completion and hence the potential flood hazard area should be protected and the damages caused by floods should be mitigated by the non-structural measures as much as possible. The proposed non-structural measures are as follows:

6.4.1 Retarding Basin

(1) Proposed Retarding Basin

In the Master Plan Study, five retarding areas were proposed in the Chane – Pailon Area. They are located in the upper reaches of the Rio Pailon, the Quebrada Chane and the Arroyo Los Sauces. It is expected that they contribute to attenuate the burden of the lower reach by reducing the peak discharges. It is indispensable for the basin to conserve the retarding basins because their effects are considered in formulation of the river improvement plan. The effect of each retarding basin for reducing the peak discharge is evaluated in the Chapter 4.

In this study, the proposed retarding basins are reviewed, and the type of regulation required for conservation of the retarding basin areas will be decided from the following aspects:

- From the technical aspect
  The function of the area as a retarding basin should be kept by conserving the topographic conditions. This means that land reclamation or drainage improvement of the area should be prohibited.

- From the economic aspect
  The areas proposed as retarding basins are mainly primary forest, secondary forest, swamp forest, idle land and minor grazing area. The development potential for agricultural land is low due to the poor soil conditions. Hence, the restriction of development has no significant impacts from economic aspect.

- From the environmental aspect
  The existing land use of the area is mainly forest and it is expected that there might be plenty of ecological and environmental resources. Hence, they should be protected from environmental aspect.

The proposed six retarding areas cover 123.4 km^2, including a swamp area at the Antofagasta Area (7.2 km^2). The proposed retarding basin areas are shown in Fig. 6.4.1 and their areas, land use and land classification are shown below:

No.	Related River	Area (km^2)	Present Land Use	Land Class
1	Rio Pailon	51.4	Primary Forest, Secondary Forest, Idle Land	V
2	Rio Pailon	10.6	Secondary Forest	V
3	Quebrada Chane	17.5	Primary Forest, Secondary Forest, Grazing Land	III, V
4	Arroyo Los Sauces	12.9	Primary Forest	V
5	Quebrada Meco	23.8	Secondary Forest	III
6	Arroyo Jochi, Arroyo Tacuaral	7.2	Primary Forest, Swamp Forest	V
Total		123.4		

(2) Conservation of Retarding Basins

The retarding basins should be conserved by the prohibition of any development activities such as land reclamation in the area. At present, there is the New Forest Law (Nueva Ley Forestal No.1700, 1996) as a legal background concerning land use control in and around the river, swamp and marsh areas. In those areas, the land owner does have a land property title but have no right to use the land in accordance with the Law. However, the Law concentrates upon the permanent flood area and it is not sufficient to cover the retarding basins, where are usually temporary flood areas. Hence, it is necessary to designate the areas as protected areas by the Department as soon as possible.

Furthermore, the Municipal Government has a role of land use control based on the Law under the control of UTD-PLUS, Direction of Natural Resources and Environment and Planning Division of the Department, but it does not work effectively due to the lack of power. It is necessary to enhance the capability of the organization to manage the land use control.

6.4.2 Flood Warning System

(1) Present Situation of Flood Warning in the Study Area

At present, there is only one system established in the Rio Piray, that is the "Emergency Action Plan for the Rio Piray Basin".

The Okinawa Area is suffering from the floods from the Rio Pailon and the Rio Grande. The Japanese – Bolivian Association of Okinawa Colony and the Integrated Cooperative for Agriculture and Stock Rising of Okinawa Colony (CAICO), the farmers' organizations, work in cooperation to collect the flood information through telephone from the related divisions of the Department and the Abapo town located 120 km in the upper reach of the Rio Grande. They decide and publicize flood warnings to the inhabitants in and around the expected flood area and organize inhabitants for flood fighting based on the information through their experience. They also transmit the information to the neighboring local villages.

(2) Emergency Action Plan for Flood of the Rio Piray

The Emergency Action Plan for Flood of the Rio Piray has been established by the Department to protect people in and around the City of Santa Cruz and along the river from the floods from the Rio Piray. The information and action network against floods is shown in Fig. 6.4.2. In the Plan, the SEARPI and the Civil Defense are defined as a core of the network. Their major responsibilities are as follows:

SEARPI	:	To observe water levels and to decide alert levels, To transmit the emergency information to the Civil Defense,
Civil Defense	:	To give flood warning to the people through the media, To organize activities for support, assistance and evacuation.

In the ordinary plan, the Joint Operation Center (COD) was a temporary organization and was defined to set up at each emergency occurrence. In March 1998, the Department Civil Defense Committee (CDDC) decided to establish the Department Emergency Operation Center of Civil Defense (COED) under the Direction of Interior of Department as a permanent organization working through 24 hours so as to enhance its function and effectiveness. COED is planned to be under the direct control of the Prefecto at the end of the year 1998. The role of COED is defined as a basic structure for support, rescue and immediate action for

the emergency cases caused by floods, draught, fire and other disasters that could endanger the life of inhabitants or put in risk the properties and the safety of the people in the Department. The scope of the COED also covers the disaster information publicizing as well as above activities.

(3) Proposed Flood Warning System in the Study Area

1) Flood Warning Scheme

A flood warning system is set up for 3 objectives, i.e., (i) for the observation and data evaluation, (ii) for the information transmission and publicizing, and (iii) for the evacuation of people from flood risks.

For the warning system, it is proposed to establish two core organizations, which are the Warning Center responsible for the observation and evaluation of data and the Operation Center responsible for information transmission, publicizing and evacuation. In consideration with the full use of existing organizations, the Warning Center is proposed to set up in the Strategic Planning Division of the Department, and the Operation Center is proposed to be under the COED.

At the same time, the local governments should work as an information transmission system. The warning information will be transmitted from COED to the Alcaldia level, and it will reach to the inhabitants level through the Canton / sub-Arcaldia levels.

The proposed activity and necessary enhancement of each organization are as follows:

Organization	Activity	Necessary enhancement
Warning Center in the Strategic Planning Division of the Department	-Observation and data collection of rainfall and hydrological data, -Operation and maintenance of observation system, -Evaluation of collected data and decide the alert level, -Transmittal of the judgement to the Operation Center.	- Enhancement of hydrologist and other specialist necessary for the warning system, - Enhancement of stuff and budget for the operation and maintenance of the observation system. - Coordination with related agencies, i.e., SEARPI and MACUSY.
Operation Center (COED)	-Declaration of the warning, -Information transmittal to inhabitants through local government, -Publicizing the information through radio and TV broadcasting, -Arrangement of evacuating people from flood risks.	- Coordination of the local governments in the arcaldia -- canton/arcaldia levels to formulate effective information transmittal system.

The scheme of the judgement and transmission system of the flood warning is summarized in Fig. 6.4.3.

2) Flood Warning System

For the flood warning system, it is proposed for the Study Area that the warning is decided based on the rainfall data collected at the existing stations and three categories of warning are applied. The proposed rain gauges to be used for the warning are:

- Saavedra (daily rainfall data is collected at present)
- CETABOL (hourly rainfall data is collected at present)
- Trompillo (daily rainfall data is collected at present)
- San Juan de Yapacani (daily rainfall data is collected at present)

The capability of these stations excluding CETABLOL needs to be improved to collect the hourly rainfall data for the judgement of the warning.

The proposed warning categories consist of following levels:

- Alert Level 1 : for rainfall with return period 2 years
- Alert Level 2 : for rainfall with return period 5 years
- Alert Level 3 : for rainfall with return period 10 years

The warning judgement process is summarized in Fig. 6.4.4 and the proposed improvement of the observation network is shown in Fig. 6.4.5.

In addition, it is proposed to establish a warning system for the floods from the Rio Grande in the Chane – Pailon Area. This warning system is to be based on the water level at the upper reach of the Rio Grande due to the characteristics of the river. A new river gauging station is proposed to be installed at Abapo for that system.

6.4.3 Flood Plain Management

This measure should be applied for the whole flood hazard area. The flood plain management consists of the following items:

- Preparation and publicizing of potential flood hazard area map,
- Land use management plan,
- Improvement of the farming system (by land use management and cropping system).

The potential flood hazard area map will contribute to the inhabitants to cope with the floods by flood proofing, protecting properties and agricultural crops.

In order to reduce flood damages, land use management is proposed to improve the existing land use and farming system. The existing land use in the flood hazard area is to be studied based on the land classification and potential flood conditions. The components of the farming system improvement are as follows:

- To specify the farming area suitable or unsuitable for farming based on the flood conditions and soil conditions,
- To propose suitable cropping systems for the flood hazard area, introducing water tolerant varieties or flood proof farming system with polder field or ridging mount,
- To propose a suitable land use to make agricultural production stable and sustainable. Introducing the proper cultivation method in the proper land potential will fulfill it,
- The implementation organization or institution is also important to succeed in the introduction of the flood plain management. The public organization, which assists to extend the proper farming system and to organize farmers' groups, is necessary to be reinforced or established.

6.4.4 Flood Evacuation Plan

To protect the lives and properties of inhabitants, it is necessary to provide them with a flood evacuation plan and to promulgate the plan to inhabitants. In the Study, the possible evacuation routes and refugees are identified.

In the evacuation plan, the possible facilities for refuges are shown as follows:

Facility	Expected Activity
School	as a shelter
Police Station	as an information transmission and rescue station
TV/Radio Station	as an information transmission center
Hospital	as a first aid station
Community Center	as a shelter
Military Base	as an operation center and rescue station
Municipality Authority	as an operation center and information transmission
Road	as a evacuation route

The conditions of public facilities and road networks in the flood season are studied as the basic information. The existing major public facilities are shown in Fig. 6.4.6 and listed in Table 6.4.1. And the road condition during the rainy season is shown in Fig. 6.4.7.

The refuge area of each area is studied under the condition that there is at least a hospital and school which will not suffer from the inundation as a first-aid center and shelter. The proposed refuge area are shown below:

Area	Refuge Area
Chane-1 (down stream)	Puerto Fernandes
Chane-2 (mid-stream)	Saavedra
Pailon	Okinawa 1
Okinawa	Okinawa 1
San Juan	San Juan
Antofagasta-1 (west)	San Juan
Antofagasta-2 (east)	San Carlos

The location of the proposed refuge area and evacuation route is shown in Fig. 6.4.8.

The major public facilities in the proposed refuge area have not been inundated even in the 1992 floods and the 1997/98 floods. However, some of the evacuation routes have been affected by floods in some distance, so it is recommended to elevate the road surface level using the disposal soils from the river and drainage improvement proposed in the project.

6.4.5 Protection Forest

The conservation of the existing forest along the river channels is very important from the technical and environmental aspects. The forests along the river channels have an effect to protect the river channels from the disordered development. Furthermore, the forests along the river channels are rich in ecological resources.

In the Master Plan Study, the conservation of protection forests along the river channels were proposed to be 1 km wide along both banks for the major rivers and 100 m wide along both banks for the tributaries.

After the Master Plan Study, the New Forest Law (Nueva Ley Forestal No.1700) has been enforced since 1996, which regulates the land use from 10 m to 100 m of both banks of river channels or swamp areas depending on their scales as mentioned in Chapter 9. The classification of the protection area is summarized as below:

Category	Regulated Protection Area
Swamp and marsh areas	50 m wide around the area The area flooded temporarily and usually used for agriculture is excluded from the regulation.
Small River *Quebrada* and *Arroyo* are categorized in this group	10 m wide of both sides of river channels for non-flood area, and 20 m wide of both sides of river channels for flood area
Large River *Rio* is categorized in this group	50 m wide of both sides of river channels for non-flood area, and 100 m wide of both sides of river channels for flood area

In accordance with the review of the plan proposed in the Master Plan Study, the protected forest along the internal rivers in the study area is set as shown below based on the New Forest Law. However, the large rivers like the Rio Grande and Rio Yapacani require one km wide of the protection forest at both sides because her floods

cause a heavy influence to the areas along the river and the rive channel itself is still unstable.

River	Proposed Protection Forest
The Chane - Pailon Area	
Rio Chane and Rio Pailon	100 m wide of both sides of the river channels
Rio Grande	1,000 m wide of both sides of the river channels
The San Juan - Antofagasta Area	
Arroyo Yapacanicito, Arroyo Jochi and Arroyo Tacuaral	20 m wide of both side of the river channels
Rio Yapacani	1,000 m wide of both side of the river channels

The river channel improvement by widening is proposed as structural measures in the Study Area and the forest along the river channels is to be deforested for this purposes, therefore, the width of the protection forest becomes more narrow locally than that of the regulation. In that case, the necessary reforestation will be proposed in the Project.

The reforestation of the protected forests is proposed in the areas where the protected forests will be cut due to the river improvement. The areas proposed for the reforestation are as follows:

Area for reforstation	Length (km)	Area (ha)
Along the Rio Chane	2.9	58.0
Along the Rio Pailon	1.5	30.0
Along the Arroyo Yapacanicito	6.6	26.4
Along the Arroyo Jochi and Tacuaral	6.4	25.6

At present, the responsibility for control of the land use and the conservation of protection forest is shifted to the Municipality authorities under the decentralization policy in Bolivia. Even they manage the land use under the cooperation of the Department, it is observed to be insufficient in the power and capability due to the lack of budget, human resources and experience. It is necessary to enhance their powers and capabilities to control the land use.

6.4.6 Flood Hazard Map

The results of above studies for the non-structural measures will be arranged and shown in a flood hazard map as the basic information to support the responsible organizations to conduct the non-structural measures and to contribute to the public information and education. The proposed flood hazard map is shown in Fig. 6.4.9.

6.4.7 Implementation Program for Non-structure Measure

(1) Implementation Program

The non-structural measures can be implemented easier than the structural measures because they do not take a large investment but require the preparation of the organization and regulation. Hence, the non-structural measures are proposed to implement as soon as possible in prior to the structural measures. The proposed implementation programs for the non-structural measures are shown in Table 6.4.2.

(2) Required Activities and Responsible Organizations

To implement the non-structural measures, both of the government of the Department and the local government of Municipality will have the responsibility in each level. The activities of the non-structural measures required for each level are shown in Table 6.4.3.

The local governments of the Municipalities are going to have a large responsibility for the required activities for the non-structural measure such as land use control due to the decentralization policy of the Government of Bolivia at present. However, they are still in low capability for those activities due to the lack of budget, human resources and experience. Hence, an adequate support and guidance by the Department is very important to realize their effective activities.

TABLES

TABLE 6.1.1 RIVER IMPROVEMENT WORKS

Project Item	Length (km)	Channel Width (m)	Bed Width (m)	Channel Depth (m)	Slope	Flow Area (m^2)	Design Discharge (m^3/s)
1. Chane-Pailon							
(1) Rio Chane	**26.350**						
Chane Bridge- Jct. Qda. Chacras	5.100	100.0	76.0	6.0	1/2	528.0	1.900
Jct. Qda. Chacras - Jct. Rio Pailon	21.250	75.0	51.0	6.0	1/2	378.0	1.600
(2) Rio Pailon	**31.680**						
1) Rio Pailon (downstream)	**23.630**						
Jct. Rio Chane - National Road No.9	23.630	70.0	50.0	5.0	1/2	300.0	900
2) Rio Pailon (upstream)	**8.050**						
National Road No.9 - Jct. Arroyo Los Sauces	8.050	65.0	45.0	5.0	1/2	275.0	760
2. San Juan-Antofagasta							
(1) San Juan							
1) Arroyo Yapacanicito	**17.360**						
Downstream - Midstream	3.560	35.0	23.0	3.0	1/2	87.0	202
Midstream - Up stream	13.810	30.0	18.0	3.0	1/2	72.0	57
(2) Antofagasta							
1) Arroyo Jochi	**11.800**						
Downstream - Midstream	8.460	30.0	16.0	3.5	1/2	80.5	106
Midstream - Up stream	3.340	22.0	8.0	3.5	1/2	52.5	71
2) Arroyo Tacuaral	**5.800**						
Downstream - Midstream	5.800	26.0	10.0	4.0	1/2	72.0	176

TABLE 6.1.2 BRIDGE CONSTRUCTION OF RIVER IMPROVEMENT WORKS

Project Item	Location	Existing Bridge				Proposed Bridge			
		Type	L (m)	W (m)	H (m)	L (m)	W (m)	H (m)	Type
1. Chane-Pailon									
(1) Rio Chane									
Bridge Reconstrcution- 1	km 2.490	RC	15.0	5.0	4.0	115.0	5.5	10.5	B
Bridge Reconstrcution- 2	km 7.550	Wood	28.0	5.0	5.0	83.5	5.5	10.0	B
Bridge Reconstrcution- 3	km 15.910	Metal	16.0	5.5	7.0	82.0	5.5	11.0	B
Bridge Reconstrcution- 4	km 21.730	Wood + RC	22.0	5.0	10.0	86.5	8.0	11.0	A
(2) Rio Pailon									
1) Rio Pailon (downstream)									
Bridge Reconstrcution- 1	km 28.660	Wood	20.0	5.0	9.0	75.0	5.5	8.0	B
2) Rio Pailon (upstream)									
2. San Juan-Antofagasta									
(1) San Juan									
1) Arroyo Yapacanicito									
Bridge Reconstrcution- 1	km 12.710	Rock Concete	17.0	6.0	4.0	34.0	5.5	6.0	B
(2) Antofagasta									
1) Arroyo Jochi									
Bridge Reconstrcution- 1	km 2.920	Wood + RC	11.0	5.0	5.0	36.0	5.5	7.0	B
Bridge Reconstrcution- 2	km 9.610	Rock Concrete	17.0	6.0	3.0	24.5	5.5	6.5	B
2) Arroyo Tacuaral									
Bridge Reconstrcution- 1	km 3.050	RC	14.0	5.0	4.5	30.0	5.5	8.0	B

TABLE 6.1.3 INUNDATION CONDITION WITH AND WITHOUT PROJECT IN 10-YEAR FREQUENCY FLOOD

(km^2 / %)

	Inundation Condition	Chane - Pailon Area					
		Rio Chane Basin		Rio Pailòn Basin		Okinawa Drainage Basin	
Without Project	Whole Area	143.7	100.0%	270.9	100.0%	185.0	100.0%
	d > 0 cm	132.0	91.8%	244.8	90.4%	110.6	59.8%
	d >= 30 cm	118.9	82.7%	210.1	77.6%	90.4	48.9%
	d >= 100 cm	75.8	52.7%	122.4	45.2%	43.3	23.4%
With Project	Whole Area	143.7	100.0%	270.9	100.0%	185.0	100.0%
	d > 0 cm	127.5	88.8%	80.3	29.6%	24.7	13.4%
	d >= 30 cm	97.8	68.1%	41.3	15.2%	0.0	0.0%
	d >= 100 cm	51.7	36.0%	4.6	1.7%	0.0	0.0%

	Inundation Condition	San Juan - Antofagasta Area			
		San Juan Area		Antofagasta Area	
Without Project	Whole Area	369.3	100.0%	238.0	100.0%
	d > 0 cm	337.8	91.5%	231.6	97.3%
	d >= 30 cm	261.2	70.7%	160.8	67.6%
	d >= 100 cm	112.0	30.3%	34.9	14.7%
With Project	Whole Area	369.3	100.0%	238.0	100.0%
	d > 0 cm	215.3	58.3%	108.6	45.6%
	d >= 30 cm	169.1	45.8%	21.9	9.2%
	d >= 100 cm	96.5	26.1%	8.6	3.6%

TABLE 6.1.4 BILL OF QUANTITY OF RIVER IMPROVEMENT AND ROAD-CUM-EMBANKMENT

Work Item	Clearing & Grubbing (m^2)	Soil Excavation (m^3)	Soil Transportation (m^3)	Sruplus Soil Filling (m^3)	Slope Forming (m^2)	Operation Road (m^2)	Bridge Construction (pcs / m)	
RIVER IMPROVEMENT								
1. Chane - Pailon Area	1,740,960	14,834,785	14,834,785	14,834,785	0	406,224	5	442.0
(1) Rio Chane	790,620	5,638,360	5,638,360	5,638,360	0	184,478	4	367.0
(2) Rio Pailon	950,340	9,196,425	9,196,425	9,196,425	0	221,746	1	75.0
1) Down stream	708,960	7,776,983	7,776,983	7,776,983	0	165,424	1	75.0
2) Upstream	241,380	1,419,442	1,419,442	1,419,442	0	56,322	-	-
2. San -Juan - Antofagasta Area	1,108,860	1,409,299	1,409,299	1,409,299	0	258,734	4	124.5
(1) San Juan Area	520,890	688,911	688,911	688,911	0	121,541	1	34.0
1) Arroyo Yapacanicito	520,890	688,911	688,911	688,911	0	121,541	1	34.0
(2) Antofagasta Area	587,970	720,388	720,388	720,388	0	137,193	3	90.5
1) Arryo Jochi	414,000	366,475	366,475	366,475	0	96,600	2	60.5
2) Arroyo Tacuaral	173,970	353,913	353,913	353,913	0	40,593	1	30.0
Grand Total	2,849,820	16,244,084	16,244,084	16,244,084	0	664,958	9	566.5

Work Item	Clearing & Grubbing (m^2)	Slope Forming (m^2)	Soil Filling (m^3)	Base Course (m^2)
ROAD-CUM-EMBANKMENT				
Road-cum-embankemnt	73,710	58,963	163,400	34,398

TABLE 6.2.1 DRAINAGE IMPROVEMENT WORKS

Project Item	Length (km)	Channel Width (m)	Bed Width (m)	Channel Depth (m)	Slope	Flow Area (m^2)	Design Discharge (m^3/s)	Remarks
1. Chane-Pailon								
(1) Rio Chane								
(2) Rio Pailon								
1) Rancha Chico	**3.600**							
Jct. Rio Pailon (down) - Jct. Rio Pailon (up)	3.600	42.0	26.0	4.0	1/2	136.0	109.0	
2) El Chaco	**1.470**							
Jct. El Empalme II - National Road No. 9	1.470	30.0	16.0	3.0	1/2	69.0	137.7	
3) El Enpalme II	**5.290**							
Jct. Rio Pailon - Jct. El Chaco	0.690	35.0	19.0	4.0	1/2	108.0	193.0	
Jct. El Chaco - National Road No. 9	4.610	18.0	6.0	3.0	1/2	36.0	50.9	
(3) Okinawa Drainage	**21.650**							
Downstream - Midstream	19.840	28.0	12.0	4.0	1/2	80.0	249.0	
Midstream - Upstream	1.810	25.0	13.0	3.0	1/2	57.0	116.0	
2. San Juan-Antofagasta								
(1) San Juan								
1) San Juan Main Drainage	**34.950**							
km 11	2.410		As is				33.2	Canal Rehabilitation
km 13	3.660	13.0	4.0	3.0	1/1.5	25.5	55.7	
km 15	8.930		As is				49.7	Canal Rehabilitation
km 17	3.840	12.0	4.5	2.5	1/1.5	20.6	41.9	
km 24	5.560		As is				18.2	Canal Rehabilitation
km 28	10.550		As is				63.9	Canal Rehabilitation
2) Arroyo Tejeria	**8.160**							
Jct. Rio Yapacani - Upstream	4.480	22.0	6.0	3.0	1/2	42.0	88.6	
Midstream - Upstream	3.680	20.0	4.0	3.0	1/2	36.0	31.5	
(2) Antofagasta								
Antofagasta Main Drainage	**8.800**							
Downstream - Midstream	5.310	28.0	12.0	3.0	1/2	60.0	222.9	
Midstream - Upstream	3.490	25.0	9.0	3.0	1/2	51.0	222.3	

TABLE 6.2.2 SUMMARY OF SECONDARY DRAINAGE IMPROVEMENT

Area	Cross Section			Number of Canals	Total Length (km)	Box Culvert	
	Surface Widht (m)	Channel Depth (m)	Slope				
1. Chane - Pailon Area							
1.1 Rio Pailon Basin	12.0	3.0	1/1.5	9	18.50	9	3.5 x 3.0 x 2battery
1.2 Okinawa Drainage Basin	12.0	3.0	1/1.5	14	35.50	17	3.5 x 3.0 x 2battery
2. San Juan - Antofagasta Area							
2.1 San Juan Area	14.0	3.0	1/1.5	18	40.50	18	3.0 x 3.0 x 3battery
2.2 Antofasta Area	14.0	3.0	1/1.5	21	35.00	21	3.0 x 3.0 x 3battery

TABLE 6.2.3 BRIDGE CONSTRUCTION OF DRAINAGE IMPROVEMENT WORKS

Project Item	Location	Existing Bridge				Proposed Bridge			
		Type	L (m)	W (m)	H (m)	L (m)	W (m)	H (m)	Type
1. Chane-Pailon									
(1) Rio Pailon									
1) El Empalme II									
Bridge Reconstrcution- 1	km 3.190	Culvert	3.0	3.5	4.8	24.0	5.5	6.0	B
(2) Okinawa Drainage									
Bridge Reconstrcution- 1	km 0.300	Brick Concrete	7.0	8.0	2.2	38.7	5.5	7.0	B
2. San Juan-Antofagasta									
(1) San Juan									
1) San Juan Main Drainage									
Bridge Reconstrcution- 1	km 13 Drainage	Culvert	12.0	4.4	5.6	18.5	8.0	6.5	A
Bridge Reconstrcution- 2	km 17 Drainage	Culvert	3.5	6.1	5.0	16.5	8.0	6.5	A
2) Arroyo Tejeria									
Bridge Reconstrcution- 1	km 7.150	RC	4.0	7.0	2.0	20.0	8.0	7.5	A
(2) Antofagasta									
1) Antofagasta Main Drainage									
Bridge Reconstrcution- 1	km 3.560	Wood	15.0	4.0	4.0	35.5	5.5	7.5	B
Bridge Reconstrcution- 2	km 6.250	Wood + RC	3.5	3.5	4.0	30.0	5.5	6.7	B

TABLE 6.2.4 BILL OF QUANTITY OF DRAINAGE IMPROVEMENT

Work Item	Clearing & Grubbing (m2)	Soil Excavation (m3)	Soil Transportation (m3)	Sruplus Soil Filling (m3)	Slope Forming (m2)	Operation Road (m2)	Bridge Construction (pcs / m)	
1. Chane - Palon Area	311,010	3,451,154	2,236,154	3,451,154	0	0	2	62.7
(1) Rio Pailon Basin	311,010	814,102	397,852	814,102	0	0	1	24.0
1) Rancha Chico	108,000	226,306	226,306	226,306	0	0	0	
2) El Empalme II	158,850	146,715	146,715	146,715	0	0	1	24.0
3) El Chaco	44,160	24,831	24,831	24,831	0	0	0	
4) Secondary Drainage	0	416,250	0	416,250	0	0		
(2) Okinawa Dranage Basin	0	2,637,052	1,838,302	2,637,052	0	0	1	38.7
1) Okinawa Main Drainage	0	1,838,302	1,838,302	1,838,302	0	0	1	38.7
2) Secondary Drainage	0	798,750	0	798,750	0	0		
2. San Juan - Antofagasta Area	1,558,530	2,663,367	668,332	2,663,367	0	0	5	121
(1) San Juan Area	1,294,620	1,232,553	235,053	1,232,553	0	0	3	55.0
1) San Juan Main Drainage (Km 13,17)	225,660	92,560	92,560	92,560	0	0	2	35.0
2) San Juan Main Drainage (Km 11, 15, 24, 28)	824,160	32,699	32,699	32,699	0	0	0	
3) ArroyoTejeria	244,800	109,794	109,794	109,794	0	0	1	20.0
4) Secondary Drainage	0	997,500	0	997,500	0	0		
(2) Antofagasta Area	263,910	1,430,814	433,279	1,430,814	0	0	2	65.5
1) Antofagasta Main Drainage	263,910	433,279	433,279	433,279	0	0	2	65.5
2) Secondary Drainage	0	997,535	0	997,535	0	0		
Grand Total	1,869,540	6,114,521	2,904,486	6,114,521	0	0	7	183.2

TABLE 6.4.1 CONDITION OF MAJOR PUBLIC FACILITIES IN AND AROUND THE STUDY AREA IN 1992 FLOOD

Area / Facilities	Floodding Condition			Activity in Flood Duration
	Inundation Depth	Inundation Duration	Period not working	
CHANE-PAILON AREA				
MINERO				
Alcaldia	Not Flooded			Coord. Evacuat. & Food
Schools	Not Flooded			Shelter
Hospital	Not Flooded			Medical Assitance
Radio Station	Not Flooded			Broadcast Information
PUESTO FERNANDEZ				
Schools	Not Flooded			Shelter
Radio Station	Not Flooded			Broadcast Information
Hospital	Not Flooded			Medical Assistance
CHANE				
Schools	1.5 m	21 days	90 days	-
Hospital	DID NOT EXIST			-
LA PORFIA				
Military Base	1.0 m	15 days		-
OKINAWA I				
Alcaldia	Not Flooded			
Schools	Not Flooded			
Hospital	Not Flooded			
Community Center	Not Flooded			
OKINAWA II				
Schools	Not Flooded			
TAJIBO				
Schools	0.6 m	7 days	15 days	-
LA ESPERANZA				
Schools	1.0 m	30 days	45 days	-
SAAVEDRA				
Alcaldia	Not Flooded			Coord. Evacuat. & Food
Schools	Not Flooded			Shelter
Hospital	Not Flooded			Medical Assistance

Area / Facilities	Floodding Condition			Activity in Flood Duration
	Inundation Depth	Inundation Duration	Period not working	
MONTERO				
Subprefectura	Not Flooded			Coord. Evacuat. & Food
Alcaldia	Not Flooded			
Schools	Not Flooded			
Hospital	Not Flooded			
Police Station	Not Flooded			
Military Base	Not Flooded			
Community Center	Not Flooded			
Radio Station	Not Flooded			
SAN JUAN - ANTOFAGASTA AREA				
SAN JUAN				
Schools	Not Flooded			
Hospital	Not Flooded			
Community Center	Not Flooded			
SAN CARLOS				
Alcaldia	Not Flooded			Coord. Evacuat. & Food
Schools	Not Flooded			No need
Hospital	Not Flooded			Medical Assistance
Community Center	Not Flooded			No need
SANTA FE				
Schools	Not Flooded			No need
BUENA VISTA				
Subprefectura	Not Flooded			Coord. Evacuat. & Food
Alcaldia	Not Flooded			
Schools	Not Flooded			
Hospital	Not Flooded			
Radio Station	Not Flooded			
BUEN RETIRO				
Schools	Not Flooded			Shelter

TABLE 6.4.2 IMPLEMENTATION PROGRAM OF NON-STRUCTURE MEASURES

Proposed Non-strucure Measure	Fiscal Year											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Retarding Basin		▽ Designation of Retarding Basin Area				Implementation of Land Use Control						
Flood Warning		Preparation of Observation Network Preparation of Concerned Organization				Operation of Flood Warning System						
Flood Plain Management		Improvement of Agricultural Technical Service Organizing farmers				Providing Agricultural Technical Service						
Flood Evacuation Plan		Designation of Evacuation Area and Route Preparation of Evacuation Plan	▽ Publicising Evacuation Plan			Providing Information and Education to Inhabitants						
Protected Forest		▽ Designation of Protected Forest				Implementation of Land Use Control						
Flood Hazard Map		Preparation of Flood Hazard Map	▽ Publicising Flood Hazard Map			Providing Information and Education to Inhabitants						

TABLE 6.4.3 REQUIRED ACTIVITY OF NON-STRUCTURE MEASURES(1/2)

Proposed Non-structure Measure	Required Activity of Levels	
	Government of Department	Local Government of Municipality
Retarding Basin	- Designating the retarding basin area as a protected area - Support and guidance to the local government	- Restricting the harmful land use or development at the retarding basin area - Inspection of the land use and development at the retarding basin area - Administrative guidance to private sectors
Flood Warning	- Preparation of the Warning Center in the Planning Division of the Department - Improvement of the observation network - Coordinating the local governments into the information transmittal system - Operation and maintenance of the observation network - Implementation of flood warning through the Warning Center and the COED	- Formulate effective information transmittal system including arcaldia/canton level - Information transmittal to inhabitants though above system
Flood Plain Management	- Improving the agricultural technical service organization and system - Improving agricultural research to study on local agriculture	- Organizing farmers for smooth implementation of extension service

TABLE 6.4.3 REQUIRED ACTIVITY OF NON-STRUCTURE MEASURES(2/2)

Proposed Non-structure Measure	Required Activity of Levels	
	Government of Department	Local Government of Municipality
Flood Evacuation Plan	- Designating the evacuation facilities and the evacuation route - Improvement of the evacuation facilities and the evacuation route - Publicizing the flood evacuation plan	- Maintain the evacuation facilities and the evacuation route - Publicizing the flood evacuation plan to inhabitants
Protected Forest	- Designating the protected forest - Support and guidance to the local government	- Restricting the harmful land use or development of protected forest - Inspection of the development of protected forest - Administrative guidance to private sectors
Flood Hazard Map	- Preparation of the flood hazard map - Publicizing the flood hazard information - Support and guidance of the flood education by the local government	- Implementation of the flood education to inhabitants

FIGURES

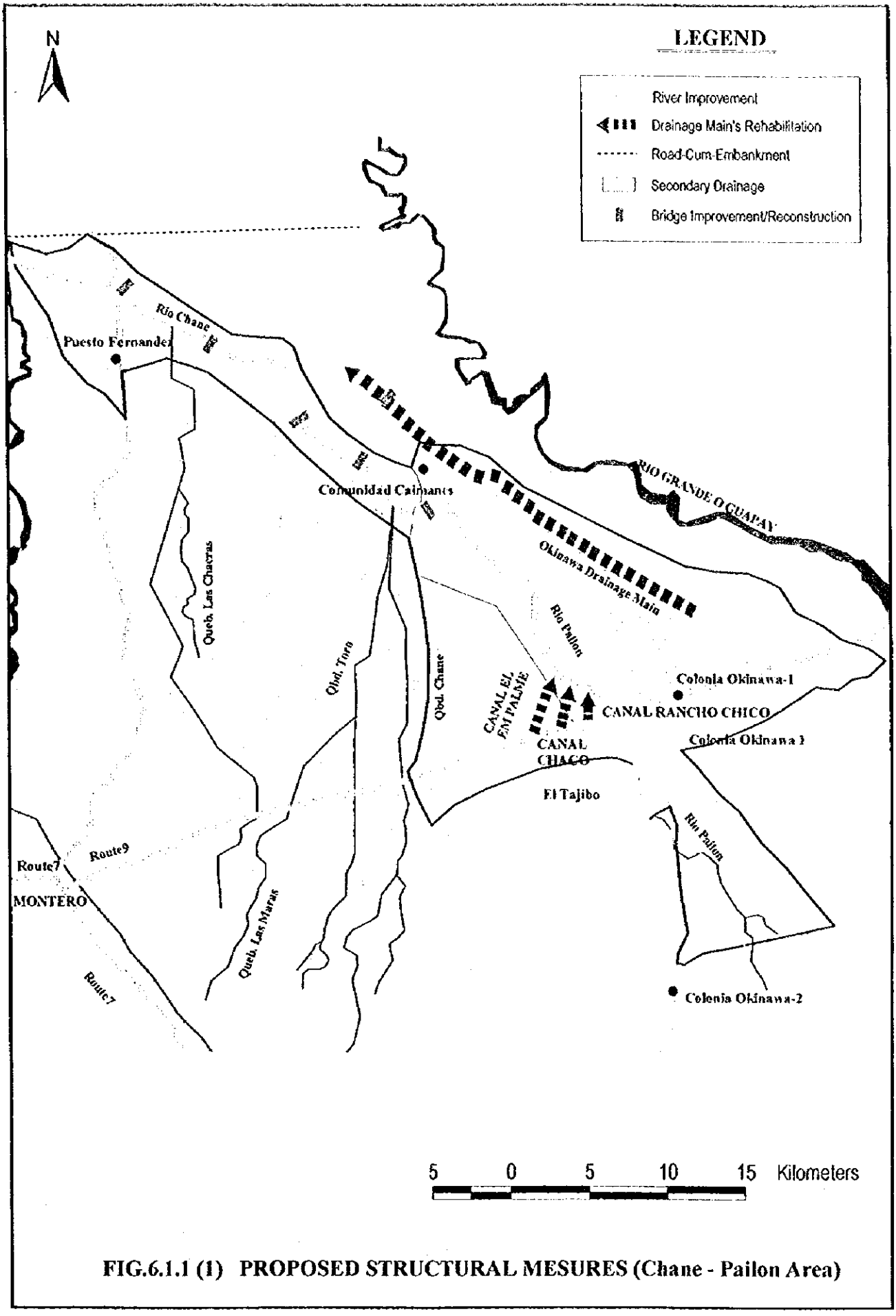


FIG.6.1.1 (1) PROPOSED STRUCTURAL MESURES (Chane - Pailon Area)