land holding (ha)	Number of household	(%)	Ratio by Sub-region (%) I	II	III	IV	V
< 1	1,796	9.3	80.0	6.0	4.7	1.8	7.5
1 - 4	9,398	48.9	70.7	12.9	9.7	3.4	3.3
5 - 9	4,201	20.8	48.8	14.5	12.5	5.1	18.8
10 - 19	2,172	11.3	37.3	14.3	15.4	5.2	27.8
20 - 49	1,070	5.6	27.0	15.2	19.1	6.6	32.1
50 <	793	4.1	9.2	14.5	42.5	15.8	18.0
Total	19,250	100.0	58.5	12.9	12.3	4.5	11.8

Source: MACA, Censo Agropecuario, 1984
CNECA, Anuario Estadistico, 1985
CODETAR, Plan Anual Operativo, 1988

(3) Producing trend of main agricultural products

The main agricultural products of Tarija Department are vegetables (tomatoes, onions, green peas, etc.), root crops (potatoes), maize, sugar canes, and fruit such as grapes and peaches. All these crops are of a relatively high profitability and marketability in spite of small cultivated area under management, and the conditions of production reflect the scale of management.

On the other hand, a large-scale cultivation of sugar cane and beans for processing materials is mainly performed in the Chaco region. The progress of planted area and production of main crops are shown in Table A.14 of Annex A. The greater part of these main crops has a approximately 20% share of the total production of the country. In particular, the yields per ha of grapes, peaches and citrus such as oranges show the highest level in the country.

2.5.3 General Features of Valle Central Region

A basin like mid-mountain areas (1,500 to 3,000 m in altitude) developing a stretch from the center to western part of the department (south latitude $21^{o}14'$ to $22^{o}14'$ and west longitude $64^{o}10'$ to $65^{o}18'$)is called "Valle Central Region". The region has 360 thousand ha, equivalent 10% of the total area of the department, and occupies 60% of the total farm household and 40% of the total present cultivated areas in the department. Thus, the region plays a role of major agricultural areas in the department. Furthermore, the region comprises four provinces and fifty-five districts including the Tarija city which is the capital of the department, and also plays a major role of socio-economic aspects.

Guadalquivir river is the main drainage course in the region originated the Sama mountain range with the elevation of 3,400 m. Seven river basins such as Toromosa, Camacho, Santa Ana, La Angostura, Pacaya and up and down stream reaches of Guadalquivir is composed of the land

form of the region. Annual mean temperature of the basin is 15.5 to 18.2 ^{o}C. Annual precipitation ranges 400 to 1,300 mm (annual mean precipitation 700 mm) and more than 90% of the precipitation concentrates during the rainy season from October to April. Out of the river basins, Santa Ana river basin has the least annual precipitation which ranges 250 mm to 740 mm. With these conditions, drastic decrease of river flow can be seen at Santa Ana river in the dry season and semi-arid situation come out in the basin.

Approximately 128 thousand ha (equivalent 35%) of eroded areas is spread over the Valle Central region with the abovementioned natural conditions and about 800 ha per year of soil erosion is now being proceeded. The amount of loss of the farm land due to the soil erosion is estimated US$ 240,000 per annum. It is pointed out that major subjects to increase the agricultural production and the improvement of the farm management in the area are the ensure the stable irrigation water and the appropriate countermeasures for the soil erosion.

The area of river basin and the distribution of the soil erosion is as follows:

River Basin	Area of Basin (ha)	(%)	Area of Soil Erosion (ha)
Guadalquivir Upstream	116,700	32.0	27,300
Tromosa	52,700	14.5	16,200
Camacho	100,300	27.6	22,600
Santa Ana	56,400	15.5	13,700
Guadalquivir Downstream	19,000	5.2	10,000
La Angosutura	7,900	2.2	3,700
Pacaya	11,000	3.0	2,300
Sub-Total (Mid-mountain)	124,000	34.6	95,800
(Mountain)	240,000	64.0	32,400
Total	364,000	100.0	128,200

PERTT - GTZ, 1989

2.5.4 Development Plan

(1) Development plan by CODETAR

In Tarija department, the Tarija Regional Development Corporation (La Corporacion Regional de Desarrollo de Tarija; CODETAR) is a leading organization in charge of determination, execution and administration of various plans which are improvement of roads, improvement of urban areas, electricity and telecommunication, industries (mining industry and agricultural product processing industry), water source development, irrigation and drainage, and agriculture and rural development.

In 1988, the CODETAR determined a "Five-year Social and Economic Plan for Tarija Department" (Plan Regional de Desarrollo Economico y

Social del Departmento para el Quinquenio, 1988 - 1992). In the development plan, 50 development projects and programs have been determined for the above-mentioned items. Including continued matters, eight projects are currently in operation. Nine projects are being executed, and the rest are in the stage of investigation. The total investment amount is approximately B.S. 412 million (US$ 149 million). About 53% of the total investment amount and 40 projects in the development plan involve agriculture and rural development including the water source development.

The CODETAR has established and possessed some processing plants for cement, glass, paper, sugar, foods, vegetable oil, and dairy products. With such facilities, the CODETAR has established a production system for processing of mining resources and agricultural products in the department, which is directly followed by sales activities. The sales of such produce account for 55% of the CODETAR's source of revenue.

(2) Agricultural development plan

In the agricultural production sector of the 5-year plan, the important development objectives include internal and external extension of cultivated areas, improvement of farmers' income through improved gross agricultural production and improved productivity, promotion of agricultural products processing, development of agricultural produce market, promotion of export, and security of stable irrigation water supply throughout the year. To achieve such objectives, the following irrigation development plans headed by water source development such as ground water supply and reservoir construction are determined in each sub-region. In addition to these water resources development, the CODETAR has being executed the "Tarija Department Land Improvement and Restoration Execution Program (PERTT)" as the project to prevent the soil erosion mainly in the Valle Central region together with the MACA and the foreign agencies since the first half of the 1980's.

Sub-region	Irrigated area
A. Sub-region I	11,000 ha
San Jacinto region	4,000
Alto Cuenca de Rio Guadalquivir reg.	4,000
Santa Ana region	1,000
Tomayapo region	1,000
Other small regions	2,000
B. Sub-region II	1,700
Pajonal region	1,200
Other small regions	500
C. Sub-region III	5,500
Provisa region	5,000
Other small regions	500
D. Sub-region IV	1,500
Basins of Carapari, Itapu and Isiri	

Out of the 5-year development plan mentioned above, the "San

Jacinto Multi-purpose Development Project (San Jacinto Multi-Proyecto)" which is under execution, the "Guadalquivir River Upper Stream Development Project (Proyecto Alta Cuenca del Rio Guadalquivir)" of which the feasibility study has been completed and the "Santa Ana Agriculture and Rural Development Project" which is under planning are the core project for the agricultural development in the Valle Central region. These projects are set up as the program to improve farmers' income and settlement at rural areas through expansion of cultivated area and improvement of productivity by means of diffusion of technical agriculture (irrigation) for small-scale farm households in the Valle Central region.

The San Jacinto Multi-purpose development Project, approximately US $18 million loan and approximately US$ 2 million aid from Italy has been confirmed, and a detailed design financed by an international organization has been determined for the "Proyecto Alta Cuenca del Rio Guadalquivir" (about US$ 20,000). General features of the both development plan is as follows:

Item	San Jacinto Project	Guadaquivir Project
Objectives	Generating & Agricultural Development	Agricultural Development
Objective Area	4,457 (3,300)ha	3,215 (960+1,930+325)ha
Farm Household	967 (631+336)	1,320
Major Facilities	Dam Type : Arch dam Height 40 m Effective storage 41 MCM Sub-dam : Rock fill	Canasmoro Area Dam Type:Concrete Gravity Height 22 m Effective storage 5 MCM Diversion channel 13.1 km Irrigation canal 42.9 km Drainage canal 31.0 km Road 20.0 km
Major Facilities		Sella Area Dam Type:Rock fill Height 44 m Effective storage 17 MCM Diversion channel 14.6 km
Average Planted Area per Farmer	4.6 ha	Model 1 : 4 ha (27%) Model 2 : 2 ha (63%)

Yield and Gross Production

Crop	Yield ton/ha	Area ha	Produc. ton
Potato	18.0	482	8,678
Onion	19.6	254	4,816
Wheat	-	825	3,134
Bean	3.0	711	2,131
Vege.	20.0	170	3,406
Maize	4.0	792	12,113
Alfalfa	-	1,410	-
Haba	6.0	139	837
Tomato	30.0	81	2,436
Grape	15.0	1,036	15,541
Fruit	18.0	255	4,581
Total		6,155	

Crop	Yield ton/ha	Area ha	Produc. ton
Potato	20.0	387	5,760
Onion	12.0	-	-
Wheat	2.0	-	-
Bean	2.5	-	-
Peanut	1.8	144	260
Veg.	13.0	192	2,500
Garlic	9.2	288	2,650
Maize	4.0	67	269
Apple	15.0	288	4,320
Alfalfa	49.0	77	3,840
		1,334	

to be continued

Item	San Jacinto Project		Guadaquivir Project	
Project Cost		US$ 1,000		US$ 1,000
	1. High system		1. Canasmoro Area	
	Major facilities	10,698	Water source	8,800
	Pipe line	7,931	Land consolidation	1,190
	Land consolidation	1,115	Credit for Agri.	840
	sub-total	19,744	Support for Agri.	211
	2. Low system	1,712	Agri. Processing	987
	Total	21,456	Road Implementation	220
	3. Dam	21,590	Administration	1,334
			Contingency	1,358
			Sub-total	14,940
			2. Sella Area	
			Water source	18,200
			Contingency	1,800
			Sub-total	20,000
			3. Others	291
			Total	35,231
Cost per ha	US$ 4,800(excluding dam)		US$ 11,000	
IRR	12 %		5.9 %	

CHAPTER 3 PRESENT CONDITIONS OF THE STUDY AREA

CHAPTER 3 PRESENT CONDITIONS OF THE STUDY AREA

3. 1 Topography

The study area is located in the east of a basin called Valle Central. It is surrounded by the Alto Grande Mountain Range in the north; the Sama Mountain Range, consisting of Negro del Chiquiuro. Muyuloma, and Huayra Khasa Mountains in the west; Alto Chico, Ladera, and Bramadero Mountains in the east; and Negro, Pena Orkho, and Sella o Minas Mountains in the south.

The area can be divided : the relatively flat river terrace area spreading along both sides of Santa Ana River, the gently sloping hilly area and the mountainous area. Several terrace surfaces clearly distinct and well developed in the river terrace area. In the hilly areas ,which the plateau is incised by the erosion, plateau configuration can be seen in the some places. Most of the current cultivated lands are concentrated in the river terrace zone where utilization of river water is available. In the plateau and hilly areas, on the other hand, farm-lands utilizing only rain-fed are scattered, and a very small percentage of the area is cultivated. In addition, the vegetation in this zone is poor; only bushes and under-growth are available, therefore, the land is often subjected to erosion.

The area distribution by altitude and the classification by land gradient in the area are shown in Fig. 3.1.1 and Fig. 3.1.2.

As the major rivers in the study area, Santa Ana, Gamoneda and San Agustin Rivers are expressed. The tributaries such as Molle Cancha and Gamoneda Rivers flow into Yesera River, which starts in the Alto Grande Mountain located the northern end in Santa Ana River basin. After joining in the study area, it becomes Santa Ana River and flows through the middle of the area from north to south. Further, San Agustin River joins it from the left side at the central part of the area and flows in the southwest direction into Guadarquivir River, which is the main river of the Valle Central.

3. 2 Meteorology and Hydrology

3.2.1 General

(1) Meteorological features

The study area is located in the mid-mountain area at an altitude of 1,800 to 1,900 m. It belongs to the semi-dry zone; the annual mean temperature is 18^{o}C, and the annual mean precipitation is 170 to 460 mm.

The precipitation of the area is the smallest in all the areas of Valle Central in Tarija Department. More than 95% of the precipitation is concentrated during the rainy season lasting from October through April, and almost no surface run-off on the rivers can be found during the dry season combined with intake at the upper area than the study area.

(2) Meteorological and Hydrological Observatories

The locations of meteorological and hydrological observatory in the Santa Ana River basin and its neighborhood and the contents of observation are shown in Fig. 3.2.1 and Table 3.2.1.

3.2.2 Meteorology

Santa Ana and La Cabana observatories are the meteorological stations in the study and observation items of these observatories are limited only rainfall. With these conditions, meteorological records except the rainfall will be used the observation value at the El Tejar university located 20 km west of the study area and the Tarija airport.

(1) General Meteorology

The general meteorology in the study area is summarized as follows.

Climate : Semi-dry and subtropical climate
Rainfall : Annual mean precipitation 170 - 670 mm
Distribution
Rainy season ; Oct. - Apr. (98% of annual preci.)
Dry season ; May - Sep. (2% of annual preci.)
Temperature : Annual mean temp. 18^{o}C
Monthly mean maximum-temp. 26^{o}C
Monthly mean minimum-temp. 10^{o}C
Relative Humidity : Annual mean 60%,
rainy season 70%, dry season 50%
Sunshine hour : Annual mean 6.9hr,
rainy season 6.2hr, dry season 7.7hr
Wind velocity : Annual mean 1.8 m/hr

(2) Rainfall analysis

1) Annual Precipitation

Utilizing the rainfall data recorded at rain gauge stations in Santa Ana River basin and its neighborhood, the correlation analysis among the stations was carried out and the areal rainfall for the last 12 years were calculated. As the results, the areal rainfall in the river basin and the rainfall in the study area are shown in Table 3.2.2. The

annual precipitations by each probable year are as follows.

Probable year (yr.)	2	5	10	50	100	200	Max.	Min.
Annual rainfall (mm)	445	331	283	216	197	180	677	167

2) Annual maximum daily rainfall

Utilizing annual maximum daily rainfall at the rain gauge stations in the Santa Ana River basin and it surrounding area , the annual maximum daily rainfall by each probable year is estimated. Out of these stations, the probable rainfall and maximum the recorded rainfall at the Tarija airport (AASANA) station, whose data is recorded for long term, is as follows.

Probable year (yr.)	10	50	100	200	500	Max. R
Probable rainfall (mm/d)	81	123	145	168	204	98

3.2.3 Hydrology

(1) Condition of surface run-off

Water level observations have been made since 1977 at the Santa Ana Bridge in the upstream part of the study area. Due to the insufficient or lacking observation period, the run-off discharge was estimated from correlation between the areal rainfall of the Santa Ana River basin and the observed data (see Table 3.2.3). According to the result, the annual run-off discharge during the last 12 years from 1977 to 1988 at the Santa Ana Water Level gauge station is estimated to be 21 MCM and the annual mean run-off coefficient is 13.5%. The run-off discharge for each probable year is as shown below.

Probable year (years)	1/2	1/5	1/10	1/20	1/50	1/100
Run off discharge (MCM)	20.582	13.343	9.805	7.001	3.981	2.032

(2) Flood Analysis

Flood analysis will be carried out utilizing the run-off data mentioned above for the water gauge station. There are some methods to estimate the flood discharge. Since the recorded rainfall data are taken daily (24 hours), the recorded period is short, and only peak flood discharge should be estimated, the maximum one among the values estimated by rational formula, SCS method and Kadoya's formula is adopted. The peak flood discharge for each probable year and largest recorded flood discharge are summarized as follows.

Probable year (yr.)	10	50	100	200	500	Max.
Peak flood discharge (m^3/s)	327	492	527	676	819	205

3. 3 Geology and Groundwater

3.3.1 General Features of Geology

Almost all the mountain areas around the Santa Ana district and the surrounding areas are mainly underlain by the alternate strata composed of sandstone and mudstone which are sedimentary rocks of the Silurian period to the Carboniferous period in the Paleozoic. Sandstone has been kept without great alteration in general and mudstone is found as phyllite in few places, and stones are dense and tight. The mountains are all steep and its weathered layer is extremely thin. Tight rocks are many exposed.

Developed structural lines extend from north-northeast to south-southwest, and all the strata are cut with the structural lines. The strike of strata is also aligned along 10^{o}N - 22^{o}E, almost in parallel with the structural lines. In the case of Cerro Barbecho and Cerro Gamoneda in the west, many dips are fairly mild to 20^{o} - 30^{o}.

On the eastern part from the Santa Ana dam site on Yesera River where a dam is planned by CODETAR, the dips are nearly 80^{o} - 90^{o}, close to a right angle. Along the valley where Yesera River flows down from the north end of the area to the point near the location where a dam is planned, rocks are continuously exposed. The general strike and dip of strata are 10^{o}N - 20^{o}E, 70^{o} - 80^{o}W, and perpendicular.

The plateau (hill zone), on the other hand, is covered with river deposits, lake deposits, and volcanic deposits of the Quaternary Period, which are broadly distributed over the zone. Partially, volcanic ashes are held between layers. In general, however, gravel, sand and clay form alternating strata, and coarse-grained deposit such as sand and gravel is only slightly superior than fine-grained deposit such as silt and clay in the ratio.

The geological features in the study area and its surrounding areas is shown in Fig. 3.3.1.

3.3.2 Groundwater

The base of the study area is composed of alternating strata with Silurian sandstone and shell in the Paleozoic. This base is exposed in the mountain area. The upper part of the base is covered by the alternating strata of diluvial gravel and clay in the plain zone, and by alluvial gravel deposit in the zone along the rivers. In the mountain area, since the base is exposed and the weathered layer is relatively thin, rainfall is the only reliable source for groundwater stored in cracks and joints on base rocks or in dislocation crash zones. Since there is almost no rainfall in the dry season, it is judged that the

quantity of groundwater is limited.

Since the base in the zone of alternating strata of diluvial sandstone and clay in the plain zone is extremely compacted, the surface layer is saturated with initial rainfall in the rainy season. The surface layer then forms a semi-impermeable layer that prevents rain water from permeating into deeper ground, limiting the ground storage. The alluvial gravel deposit extending along the rivers is relatively thick. When river water flows into this section, it become underflow. Surface run-off, therefore, can be seen in the only rainy season. Since the river gradient and the hydraulic gradient are small in this section, groundwater is stored in this alluvial gravel deposit.

There are two wells (one is 11 m deep and the other 8 m deep) in the campus of the Santa Ana Nueva Primary School. Although the well in the upper position dries up in the dry season, the other in the lower position retains 1 m of water even in the dry season, and it is used year-round. This aquifer is regarded as a part of the alluvial gravel deposit along Santa Ana River, and it is regarded as a part of underflow of the river rather than groundwater. There is an approximately 60 m deep well near the public health center in Santa Ana, but it is buried and out of use. The pump discharge rate was supposedly extremely small (water level - 18 m keeps only 10 minutes of pump discharge). There is an artificially dug-out well (13 m deep) near the said well. It keeps the water level at around ground level (-)11.5 m during the dry season. The water level rises by 2.3 - 3.5 m during the rainy season. It can be considered as the underflow, since the well is regarded to be located at riverbed gravel deposit along Santa Ana River.

Comprehensively judging from the above, the limit of the pump discharge rate of groundwater from the alluvial gravel deposit, extremely thick diluvial gravel and clay deposit in the Santa Ana area is about 500 m^3/day (1,000 m^3/day maximum).

3. 4 Soil and Present Land Use

3.4.1 Soil

(1) Soil survey

In order to obtain the basic materials which contribute to adequate land use, the following soil survey has been conducted.

1) On 250 sample pits: rough investigation for the kinds of soils and their distributions in the study area

2) On 31 pits:investigation of soil profiles and sampling for the analysis of physical-chemical properties

3) Physical-chemical analysis:analysis of physical-chemical properties making use of the samples (including core-samples)

4) Moisture tension: measurement of the moisture tension with tensiometers

Based on the results obtained, the kinds of soils and their characteristics are clarified , and the map of soil distribution is drawn up. Also, the results of the basic materials will be utilized for land classification and land use planning.

(2) General Features of the soils

In the study area, which is surrounded by mountains on three sides basinlike are formed, and Santa Ana river having branches of Gamoneda and San Agustin rivers flows from northeast to southwest. The topography is divided roughly into the terrace type which is distributed along the river banks, and the hill type which has an undulating relief. Parent material of the soils is unconsolidated sedimentary rock, mainly in the terrace type there is alluvial deposits from the river and in the hill type there is fluvial and lacustrine deposits from the diluvial era.

The area belongs to the semi-arid region of the subtropical zone. Although the annual rainfall is about 450 mm, because the dry and rainy season are separated, 95% of the total precipitation is concentrated in the rainy season. The vegetation in the area is reflected by this climate, the land of the area is almost bare so that the soil is exposed, and only sparse wood and herb vegetation are available expect the plains which have a good moisture condition. In addition, only 9% of the area is utilized for arable land.

The soil of the area can be divided into the hill and terrace type based on the topography and their parent material mentioned above.

In the hill type, in many cases, the soil horizon is undeveloped and the horizon boundary is not defined. The moisture regime is usually dry and the color is entirely light. And also, in the up stream part, near the mountain, which has a steep slope, many sub-angular or surrounded gravel appear all over the soil. Their sizes are fine to medium. The surface soil is undeveloped because the vegetation is sparse, their content of organic matter is poor and the horizon is very shallow. Its texture is mainly medium, however, some places where cultivation is being practiced, change gradually to fine texture. In the subsoil, B horizon is not developed clearly and the horizon boundary from A to C is not distinguished distinctly. Mottles and concretions of calcium carbonate appear in the subsoil, and in a part of it, hardpan has become gluey. Also, for the most part, the soil structure is rocky because of the influence of calcium carbonate.

The physical and chemical properties of the hill-type soil are as follows and soil fertility is low.

- The soil acidity shows little alkalinity to high alkalinity.
- The content of organic matter is little.
- Though the cation exchangeable capacity is relatively high, the cation saturation degree is low.
- A little of available phosphorous is contained.

In the terrace type, the topography is nearly flat and its type is utilized for cultivated land because of being situated near the river and its moisture condition is much more favorable. The texture, in the upper part of about 50 cm, is medium to fine, but in the lower is medium and surrounded by thick gravel. In the surface soil, the soil horizon is clear, the content of organic matter is more than that in the hill type and aggregates can be observed. The moisture regime is, in the upper part, usually dry but in the lower a little moist. Also at the up-stream area the Santa Ana river, the buried A horizon can be observed in a part of horizon over one meter deep.

The physical and chemical property of the terrace-type soil are as follows and the soil fertility is higher than one of the hill-type soil.

- The soil acidity shows neutrality to low alkalinity.
- The content of organic matter is relatively high (especially at surface soil).
- Though the cation exchangeable capacity is low, the cation saturation degree is high.
- A lot of available phosphorous is contained.

(3) Soil classification

The soils in the area will be classified with parent material, diagnostic horizon and its horizon sequence, color, soil structure, soil moisture regime, extent of organic sediment, soil temperature, alluvial clay horizon and results of soil analysis. The Soil Taxonomy of USDA is employed for the final classification.

Out of the soils in the study area, the hill-type soil is classified into Entisol, Fluvents and the terrace type soil into Ardisol of Ordisol and Inceptisol of Ochrepts. The soil classification to soil series is shown in Table 3.4.1. The soil orders such as Entisol, Ardisol and Inceptisol account for 250 ha (7.8%), 2,688 ha (83.8%) and 269 ha (8.4%), respectively. (except for the area where basement rock exposes gully and riverbed). Soil distribution map in the study area is shown in Fig.3.4.1.

3.4.2 Present Land Use

(1) Land classification

In classifying the land for agriculture with technical irrigation, land classification is carried out on the basis of the manual of USDA and FAO taking into account for erosion (slope, soil texture, damage of erosion), soil tilth (effective soil layer, content of gravel and slope) and soil fertility (physical and chemical property).

The result of the land classification is as follows.

Class	Area (ha)	(%)	Remarks
Class I	0	(0)	
Class II	436	(5.7)	
Class III	904	(11.9)	
Class IV	1,867	(24.6)	
Class V	4,144	(54.6)	
Others	242	(3.2)	residential area, road and river

Land belonging to Class I through Class IV is classified into arable land and Class V and the lower class into non-arable land or land with extreme limit factor. Land classification map is shown Fig.3.4.2.

(2) Present land use

The land in the study area is classified broadly into five land categories, cultivated land, forest land, grazing land, waste land and others (residential area, roads and rivers). The total area of each category is estimated below based on the field survey, aerial photographs and other available material. The present condition of land use is shown in Fig.3.4.3.

Classification		Area (ha)	Remarks
Cultivated land	annual	537	including fallow
	perennial	112	land
Forest land		425	
Grazing land		190	
Waste land		6,087	
Others		242	residential area, road and rivers
Total		7,593	

General characteristics of each land category are as follows:

- Lands utilized for cultivation continually are situated in the river terrace because the moisture condition is favorable. Irrigation is being practiced in a part of the area. On the

other hand, in the hilly area, the low slope land is utilized for cultivation only in the rainy season. When rainfall is not available for planting, such cultivated areas proceed to fallow land without harvest.

- Forest land is situated in its moisture favorable location such as the foot of the mountain, sides and bottom of the valley which were formed by gully erosion. Although, some farmers plant trees for conservation of the land.

- Waste land is utilized for grazing of livestock in the case that the land has some vegetation.

- Occurring situation of soil erosion in the study area and its surrounding area shows the clear distinction between northwestern area and southeastern area from the department road, route 302. At the northwestern area, basement rock is sallow and a small stream is formed at the hollow without vegetable during the rainy season. However, if the surface soil would be eroded, gully is not formed due to exposure of basement rock or if gully would be formed, the gully does not progress maintaining the small scale. On the other hand, since the southwestern area is covered with the fluvial deposit and the lacustrine deposit which are composed of the alternation gravel layer and sandy silt or clay layer, and the cover of vegetable is poor, the many streams which flow into Santa Ana River are forming the gully (Quebrada) and the erosion is progressing year by year. Especially, the area surrounded by route 302 and route 3383, and the hill area on the left bank of Santa Ana River are not blessed with the water utilizing condition and the upland filed utilizing rainfall is only scattered. Since the other land is utilized as a pasture land for a domestic animal, the progress of gully erosion is extreme.

3. 5 Agriculture and Agro-Economy

3.5.1 Outline of Regional Agriculture

The study area is a upland field region that spreads over river terraces extending along the Santa Ana River basin and adjacent hilly zone. It belongs to the agricultural region of Valle Central district in the department. In the study area, there are 3 communities (comunidad); i.e., Santa Ana Nueva, Santa Ana Vieja, and San Antonio. Small-scale farmers comprise a large proportion of the population. For these farmers, the shortage of the irrigation water in the dry season is the largest factor restricting their agricultural management to a single-crop in the rainy season production for self consumption. Accordingly, because of low ratio of land utilization and salable product, such small-

scale farmers are restricted to unstable agricultural management. Their actual agricultural income is less than half of the general income.

However, the study area is topographically appropriate for the water conservation and has semi-dry climate meteorologically. Furthermore, the area is positioned as the agricultural areas at the outskirts of the urban areas and locates near the largest market in the department. Therefore, utilizing such favorable market environment and meteorological characteristics, a part of the farmers equipped with irrigation facilities can expand their profitable agricultural management by specializing vine cultivation. At present, improvement of agricultural infrastructure aiming at the stable irrigation water supply through the year is exceedingly indispensable to improve the agricultural production and management in the study area.

3.5.2 Number and Scale of Farm Household

Based on the topographic maps (scale 1/5,000, prepared by JICA, 1989) and results of the field study, the total number of farmers in the study area is 171. The distribution of farmers in each community (comunidad) is shown in the following table and Fig. 3.5.1.

Community	Num. of Farmers	%
Santa Ana Nueva	98(15)	57.3
Santa Ana Vieja	29	17.0
San Antonio de La Cabana	44(18)	25.7
Total	171(33)	100.0

( ) means number of tenant farmer

There are 33 tenant farmers in the study area, and the remainder are land-owners. Most of the land-owners in the study area obtained their ownership from the Agrarian Reform in 1953. After the land reform policy, the other type of owner farmers such as those who have inherited are most common. At present, these two types of land-owner are occupied 32.5% and 26.1%, respectively. Due to the increase of these types of farmers, fractionization of farm lands is proceeding and other farmers are enlarging their properties.

Out of these farm households in the study area, the farm households distributed in the downstream area along Santa Ana River are relatively large in the scale of farm management, and there are two farm households having more than 300 ha of holding area. On the other hand, many small-scale farmers tend to distribute in the river terrace zone apart from the river. The average area of land holding per household is estimated to be approximately 7 ha, and out of this area, 4 ha is considered to be the average arable area. The distribution of farm household in the study area is shown in Annex E, Table E.1.

3.5.3 Agricultural Production

(1) Crop area and production volume

The main crops in the study area are annual crops such as corn, wheat, potatoes and beans (arveja, garbanzo, peanuts), and vegetables (tomato, onion), and perennial vines. According to the results of the present land use survey and the field study, the total crop area, average field and production of those main crops are shown in the following table.

Crops	Area (ha)	(%)	Yield (ton/ha)	Production (ton)	remarks
1.Corn	180	32.0	0.6	108	
2.Wheat	100	17.8	0.6	60	
3.Potatoes	70	12.5	4.0	280	
4.Beans	50	8.5	0.5	25	peas, chick peas
5.Vegetable	30	5.1	5.8	174	tomatoes, onions garlic, carrots
6.Others	20	4.3	5.0	125	alfalfa
7.Grape	112	22.2	9.0	1,170	
Total	562	100.0	-	2,150	
Total cultivated land			649 (ha)		
Crop intensity			87 (%)		

Corn, potatoes, and wheat, which have a 60% share in the total cropping acreage, are planted by the majority of the farmers in the study area, but the average yields of these crops is 20 - 30% lower than that in Tarija Department. For the main reason for the low yield, the rough cultivation system based on poor fertilization control is pointed out. In case of small-scale farm households in particular, the quantity of sowing and providing fertilizer is less than 10% of investment for the production material recommended by the Agriculture Promotion Center (MACA) and the Agricultural Experiment Station (IBTA).

In the study area where the one harvest system per year depending on rainfall during the rainy season is common, the utilization of land throughout the year is difficult and the cropping rate for the total amount of arable land is low (87%). For this reason, planting is concentrated in the rainy season and the ratooning in the intercropping of corn and beans and the cultivation of wheat during the dry season is also observed. Planting during the dry season is made mainly by grape-producing farm households which are only 15% of the total farm households, and a part of vegetable-producing farm households.

The present cropping calendar of major crops in the study area is shown in Fig. 3.5.2 and the general cropping situation for these main crops is described in Annex E.1.3.

(2) Farming Pattern

The farm households in the study area can be classified into the small-scale farmer and the large-scale farmer producing grape. The small-scale farm households can be further classified into the farm households which mainly produce annual crops such as corn, wheat, and potatoes, and the farm household which produce grapes (perennial crop). Combination of crops and agricultural operation status are as follows.

A. Small-scale Farm Household

1) Average arable area : 4.0 ha
2) Average planting area: 2.2 ha
3) Farming pattern : one harvest per year (during the rainy season)

Crop	Planting acreage (ha)	Yield (kg/ha)	Production (Kg)
Corn	1.0	500	500
Potato	0.3	4,000	1,200
Wheat	0.7	550	560
Others	0.2 (Arveja, Peanuts, etc.)		
Total	2.2 (Annual cropping ratio: 55%)		

B. Small-scale Grape-Producing Farm Households

1) Average arable area : 4.0 ha
2) Average planting area: 3.0 ha
3) Farming pattern : one harvest per year (during rainy season, partially during dry season)

Crop	Planting acreage (ha)	Yield (kg/ha)	Production (Kg)
Grape	1.0	9,000	9,000
Corn	1.0	900	900
Potatoes	0.3	4,500	1,350
Others	0.7 (Wheat, Arveja, Tomato, etc.)		
Total	3.0 (Annual cropping ratio: 75%)		

C. Large-scale Farm Households Specializing in Grape Production

1) Average arable area : 55.0 ha
2) Average planting area: 40.0 ha
3) Farming pattern : two harvests per year

Crop	Planting acreage (ha)	Yield (kg/ha)	Production (Kg)
Grape	40.0	19.5	780
Others	15.0 (Corn, Potatoes, pasturage, etc.)		
Total	55.0 (Annual cropping ratio: 100%)		

The farming patterns at present are similar for all farmers and the small-scale farm households classified under type A and B shown above account for over 95% of the total number of farm households. Out of them, the percentage of the grape-producing farm households is approximately 10% (20 households). Small-scale farm households take crops except grapes for self consumption in principle, and only surplus crops are offered to the market. The yield of grapes by small-scale farm households is superior to the average yield (7.9 t/ha) in the Department, but it is still less than half of the yield in comparison with large-scale farm households specializing in grape production.

3.5.4 Farm Economy

The farming characteristics of the farm households can be summarized as follows, based on the results of agricultural farm management survey.

A	B	C	D	E	F(%)			J				Community	Remarks
			(*1)	(*3)									
	(ha)	(%)	(%)	(pns)	G	H	I	1st	(%)	2nd	(%)		
1.Upland	8	60	60	8 (7)	40	10	50	Potatoes	(70)	Wheat	(20)	Santa Ana V.	Beef Cattle (1)
2.Upland	6	55	50	6 (5)	50	-	50	Wheat	(60)	Potatoes	(30)	Santa Ana V.	
3.Upland	5	50	45	8 (6)	30	10	60	Potatoes	(60)	Beans	(20)	San Antonio	Beef Cattle (2)
4.Upland	4	40	40	8 (7)	30	-	70	Potatoes	(70)	Beans	(20)	Santa Ana N.	Beef Cattle (1)
5.Upland	2	50	50	5 (5)	20	80	-	Potatoes	(80)			Santa Ana N.	
6.Upland	9	60	70	6 (6)	90	10	-	Potatoes	(80)	Tomato	(10)	Santa Ana V.	
7.Upland & Orchard	8	50	65	5 (5)	100	-	-	Grapes	(80)	Potato	(10)	Santa Ana V.	Beef Cattle (1)
8.Livestock	12	50	90	absence	100	-	-	Daily cattle	(100)			Santa Ana N.	Beef Cattle(20)
9.Orchard	300	20	100	11(11)	100	-	-	Grapes	(100)			Santa Ana V.	
10.Orchard	369	20	110	8 (6)	100	-	-	Grapes	(100)			Santa Ana V.	Beef Cattle(12)

Note) A: No of farming pattern, B: Area of land holding, C: Rate of arable land,
D: Cropping Intensity, E: Number of family, F: rate of farm income, G: agriculture
H: Non-agriculture, I: Work out the area, J: Rate of agricultural income
(1) Objective farm household: 22 houses
(2) (*1): Cropping intensity for farmland
(3) (*2): monthly mean number
(4) (*3): Non-agricultural income;
labor of road improvement, labor at farm (grape farm, stock farm)
(5) Orchard and Upland: Grape and Upland
(6) Orchard: Grape

From the above farming characteristics, the following facts can

be pointed out.

a. In the case of small-scale farm households belonging to Type 1 - 5, more than 50% of the income depends on non-agriculture income or working in other place, and it is difficult to make a living only by agricultural income. On the other hand, in the case of small-scale households producing grape, farm management is maintained only with agricultural income supported by the high profitability of grapes, but almost no surplus profit is obtained due to compensation of the living expenses.

b. In the case of small-scale farm households, in spite of a high planting ratio of upland crops (for corn and wheat), the crops fail to produce substantial income for the farmers, because the ratio of own-consumption is large compared with the production volume.

c. At present, the current producer prices for main crops in the study area, excepting the price of grapes and cash crops (garlic, tomato and etc.), are at nearly the same level. Therefore, the price condition is not absolute important items for their decision of planting. Instead, the condition for stable production, though small, tends to be considered as the most important condition.

d. From the components of the present farmers' income, it seems that an improved cropping ratio in the rainy season alone is not sufficient to compare with the total of non-agricultural income. Therefore, for improvement of farm management through increased agricultural income, it is necessary to improve agricultural productivity with increased yields of major crops per ha, based on an improved cropping ratio with the year round cultivation and introduction of fruit cultivation such as grapes as a major crop with proven profitability.

Farm income by farming pattern is as follows. At present, the average income of urban laborers is Bs.7,200 to 8,400 per year (Bs.600 to 700 per month). Compared with this, both the average living expenses and the average income of the farm households in the study area are less than half those of urban laborers. Furthermore, the farm income is less of 30 to 40% than one of Guadarquivir and San Jacinto areas which is located near the study area. (Refer Annex E, Table E.2)

Pattern	Income (Bs./year)			Living Expense
	Agri.	Non-agri.	Total	(Bs./mon)
A. pattern 1 - 5	650	2,400	3,050	3,000 (250)
B. pattern 6 & 7	3,000 - 3,600	-	3,000 - 3,600	3,600(300)

3.5.5 Marketing and Distribution of Agricultural Products

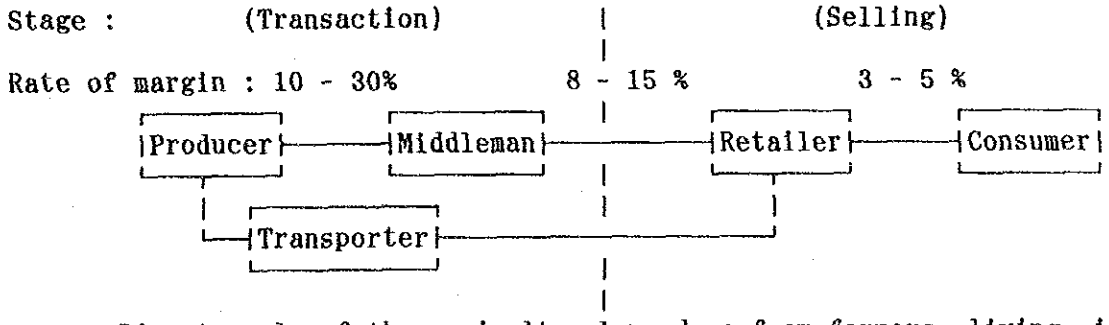
(1) General

There are six major agricultural markets in Tarija city, such as Mercado Campesino, Central, La Paz, Boris Banzar, Bolivar and Villa Fatima. These major markets have built up the biggest market as distributors and shippers of agricultural produce in the department, and furthermore they appear to be the major supply of basic food to the regional inhabitants.

The study area is located in a radius of 25 km from these major markets. Despite the favorable environment, the shipment volume by each farm household to the market is very small because the greater part of the agricultural production is consumed by the farmers themselves, and the water shortage makes it a difficult condition for the all year-round cultivation by the small-scale farmers. In addition, difficulty of access and the scattered small-scale fields are pointed out as common obstacles of the small shipment of the agricultural produce. On the other hand, in the current distribution procedure, the low profit margin does not encourage the farmers to increase their production.

(2) Trends of the Agricultural Products Price

The distribution channel on the agricultural produce of the study area is divided into following stages. A high rate of the distribution cost (maximum 50%) is occurs because of the distribution channel.



Direct sale of the agricultural produce from farmers living in the study area to the market is difficult due to the poor transportation system and lack of know-how of sales management. Because of the basic shortage of shipping volume, and the distribution cost, producer's profit is very low at present. The trend of the agricultural produce prices in different stages such as the producer, the wholesaler and the retails can be summarized in Annex E. From the trend of the agricultural produce prices, the following facts can be pointed out.

a. Wholesaler's price and consumer's price are stabilized at the high price range throughout the year. On the contrary, the

producer's price is in unstable, very varied and consistently low.

b. There is high correlation between the consumer's price and the producer's price, on the contrary, between the producer's price and wholesaler's there is a large price difference. This shows a high rate of distribution cost.

c. Based on the trend of the agricultural produce price, it is estimated that the off-season of main agricultural products in Tarija Department is : vegetables in dry season (Apr. to Sep.), beans in dry season (Apr. to Sep.) and cereals in rainy season (Oct. to Mar.)

(3) Supply and demand situation of main agricultural products.

1) Trend and present situation of food consumption

Trend of the volume of food consumption per capita of the main crops in the study area is presented in Annex E. From the trend of the volume of food consumption the characteristics of the consumption for the main agricultural products can be summarized as follows.

a. Situation of the food consumption per capita is unstable with large annual fluctuation, because consumption propensity is easily affected by the influence of the national economy, and the trend of the agricultural production and income fluctuation. In the 1970's due to the improvement of the national economy and personal income, food consumption per capita maintained a high level, therefore the purchasing potential was more stabilized than compared with the 1980's.

b. The ratio of food consumption volume due to the trend of national economy and the income fluctuation have a tendency to decrease in basic food like cereals and increase for fruit and vegetables. For these reasons, it is pointed out that income elasticity of fruit and vegetables is high. With the elevation of the living standards and capacity of supply, increase in volume of consumption of these crops can be expected.

c. In the table below is shown the comparison results of food consumption per capita per annum between Bolivia and the Argentine. Consumption volume per capita in Bolivia of basic food such as cereals, tubers and beans is the same or more than that of the Argentine. However, consumption volume of fruit and vegetable is only 1/3 to 1/7. In calorie level per capita per annum, average calorie level is 2,200 kcal for Tarija province and 1,450 kcal for the study area as against 3,110 kcal in the Argentine.

As to the calorie level of inhabitants in the study area and Tarija Department, it is necessary to improve the nutritional level in quantity as well as quality. Stable agricultural production and improvement of personal income level is essential to meet the above-mentioned requirement.

2) Present status of food supply

The progress of the cropping area, production and yield for main crops in the study area and Tarija Department is shown below.

Products	1983			1985			1988		
	A	B	C	A	B	C	A	B	C
1.Corn *	32.1	28.1	0.9	30.8	83.7	1.5	39.0	83.8	1.6
2.Wheat	9.2	4.0	0.4	6.8	5.0	0.7	6.8	5.8	0.9
3.Potatoes	7.6	20.2	2.6	8.0	27.5	3.4	8.4	42.2	5.0
4.Beans	1.7	2.0	1.1	0.9	1.3	1.4	0.9	1.3	1.4
5.Tomatoes	0.2	1.6	7.9	0.2	1.2	6.0	0.4	3.0	6.7
6.Onions	1.1	4.4	3.9	1.0	6.7	6.6	1.1	7.2	6.2
7.Carrot	0.1	0.8	7.2	0.03	0.1	N.D	0.2	7.0	N.D
8.Grapes	0.8	6,2	7.4	0.8	5.9	7.7	0.9	7.4	7.9

Note: (A) = Crop area (1.000 ha) (B) = Production (1.000 ton)
(C) = Yield (ton/ha) * Including forage.
Source: (1) Estudio de Pronosstico Agropecuario, 1985 MACA
(2) Departamento de Planificacion Sectorial MACA - Tarija. 1989.

Among the main crops, the traditional crops such as corn, wheat and potatoes show a trend of increasing in production with the improvement of productivity and the increase of the cultivated area during the last six years (1983 - 1986). Because, yield and demand for these crops are stable and farmers' intention for planting are specialized to these traditional crops, since these crops are cultivated mainly for auto-consumption purpose. On the other hand, annual production change of vegetables and beans are great, these conditions originate in the unstable market price through-out the year and the difficulty of storage. By contrast, among the exportable vegetables such as tomatoes, onions and garlic and perennial grapes they are showing a sharp increase, supported by the high profit and income rate.

3) Prospect for supply and demand of food

The growth rate forecast of food consumption, population growth, domestic produce (gross income) and total consumption value in Tarija Department for the year 2000 is shown below. It is estimated that more than 60% of the population with live in the urban area by the year 2000 though present population ratio is nearly equal between the urban and rural areas. Parallel to this population trend, the expansion of the demand for agricultural products can be expected. The stable supply of

fundamental food will be problem in future.

Year	Population (1,000)			Gross Production	Total consumption
	Tarija	Urban	PEA	US$ million	US$ million
1987	285.0	145.9	91.1	258.9	243.4
1992	348.9	181.1	111.3	408.2	394.6
1995	407.6	221.7	130.0	481.5	464.5
2000	530.0	318,0	166.0	645.5	620.9
growth rate	4.9 %	6.2 %	4.7 %	5.4.%	5.2 %

Note : PEA =Economically Active Population
Source : (1) Documento preparado por la Presidencia y la Gerencia de Planificacion y Proyectos, CODETAR, 1989
(2) Plan Quinquenal Desarrollo Tarija 1988-1992,CODETAR

Prospects for the supply and demand of the main food in the year 2000 are summarized below, based on the population trend mentioned above and the present trend of supply and demand of agricultural products.

Product	1988				2001				Remarks
	A	B	C	D C/B(%)	A	B	C	D C/B(%)	
1.Cereals									
Corn	107	31.6	57.6	180	120	48.9	69.9	142	12.3
Wheat	60	17.8	4.6	25	70	28.5	7.6	26	3.0
2.Tubers	180	53.3	31.1	58	180	73.4	45.5	31	14.4
3.Beans	6.4	1.8	1.4	78	8	3.2	3.5	100	2.1
4.Vegetables									
Tomatoes	9.5	2.8	2.2	78	20	8.2	4.6	56	2.4
Onions	10	3.0	5.9	190	20	8.2	10.7	130	4.8
Garlic	2	0.6	1.7	280	4	1.6	4.6	287	2.6
Carrots	5.4	1.6	0.4	25	10	4.1	0.4	10	-
Supply rate	-	-	-	93	-	-	-	86%	-
Vegetables supply rate	-	-	-	115	-	-	-	76%	-

Note: a) A: Food consumption per capita (kg)
B: Total consumption in the Department (1.000 ton)
C: Total production in the Department (1.000 ton)
D: Supply rate (%)
b) Present consumption volume per capita taken from the maximum value during 1976-1985. Consumption volume per capita in the year 2000 is estimated based on the consumption volume trend in the Argentine and Bolivia.
c) Total consumption in the Department = total population in the Department x food consumption per capita.
d) Total production of 1988 taken from the average agricultural production volume of 1983-1988 in the Department. Total production of 2000 taken from total production of 1988 plus projected production shown in the Remarks.
e) Remarks: Mean total projected agricultural production in San Jacinto Multi-purpose Project and Guadarquivir project (unit 1.000 ton).

Source: a) Estudio de pronostico Agropecuario, 1985 MACA
b) Departament de Planificacion Sectorial MACA-Tarija,1989.

c) Plan Anual Operativo, 1988 CODETAR
d) Proyecto de Desarrollo Agropecuario en la Alta Cuenca del Rio Guadalquivir,1987,8 Proyecto Multiple "San Jacinto", 1980.
e) Propuestas para una Estrategia de Desarrollo Rural de Base Campesino, 1985.

In deciding on the prospects supply and demand of projected production volume of the Guadarquivir and the San Jacinto Multi-purpose Projects which are located near the study area, is considered.

Looking at the situation of supply and demand at departmental level all basic food crops except corn are in short supply. Among them, vegetable, onions and garlic are produced mainly exported, therefore, these two crops keep a high supply level.

3.5.6 Production of Wine

(1) Wine making

It is estimated that the total production of wine and liquor in the nation (1985) is approximately 4,114 million bottles. Out of this, Tarija Department accounts for 70% of the total production. There are two wineries in the study area, and their annual production is equivalent to approximately to 60% of the total production in Tarija department. The wineries in the study area employ 80 regular employees and 100 - 200 seasonal laborers during the grape harvesting season, and they offer a major opportunity of employment in the study area. The wine production in the Tarija Department has tended to increase and expand their winery facilities in the last ten years (1976-1985). According to the 6 main wineries in Tarija Department, the annual average wine production increase rate in the period 1986-1995 is expected to be 3.5.%, and total wine production is estimated approximately 4.30 million bottles in the year 1995.

Year	CASA REAL	DAROCA	ARENA	KOHLBERG	ARANJUEZ	GUADAL-QUIVIR	Total
1986	449	116	6	1,346	848	150	2,914
1987	467	121	7	1,393	899	156	3,042
1988	486	128	7	1,441	953	162	3,176
1989	505	134	7	1,492	1,010	168	3,316
1990	526	140	7	1,544	1,071	175	3,463
1991	547	147	8	1,598	1,135	182	3,617
1992	568	155	8	1,654	1,203	189	3,778
1993	591	163	9	1,712	1,275	197	3,946
1994	615	171	9	1,772	1,352	205	4,123
1995	639	179	9	1,834	1,433	213	4,308
*(%)	4.0	5.0	4.5	3.5	6.0	4.0	4.5

Note: Annual increase rate 1986-1995
Source a) JICA Field Survey, 1989
b) Elaboration CODETAR, 1985

(2) Demand and supply situation of wine and liquor

Most part of the demand and the consumption propensity of wine and liquor depend on the income level and brand name, therefore, in the first half of the 1980's operation rate of the above-mentioned six wineries dropped to 65% owing to the national economic depression. CODETAR as reported that there is a three times difference of wine consumption per year between the lower income group (consumption 4 bottles per year) and high income group (consumption 12 bottles per year).

According to the increasing ratio of the liquor consumer and consumption propensity, the estimated demand of wine and liquor for the next decade (1986-1995) is as follows.

(Unit: 1,000 bottle)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Tarija	344	352	360	368	376	385	393	403	412	422
Nation	5927	6069	6215	6364	6517	6673	6834	6998	7166	7337
Total	6271	6421	6575	6732	6893	7058	7227	7401	7578	7759

Source: a) JICA Field Survey 1989
b) Elaboration CODETAR, 1985

(3) Balance of supply and demand

The balance of the supply and demand for wine and liquor based on the wine production plan and the estimated demand in Tarija Department and the nation as a whole are summarized below.

(Unit: 1,000 bottles)

Year	Tarija			Nation		
	Demand (A)	Supply (B)	(C) (B)/(A)	Demand (A)	Supply (B)	(C) (B)/(A)
1986	344	2,914	849 %	6,271	4,214	67 %
1987	352	3,042	866 %	6,421	4,381	68 %
1988	360	3,176	884 %	6,575	4,555	69 %
1989	368	3,316	903 %	6,732	4,737	70 %
1990	376	3,463	921 %	6,893	4,926	72 %
1991	385	3,617	939 %	7,058	5,124	73 %
1992	393	3,778	961 %	7,227	5,330	74 %
1993	403	3,946	981 %	7,401	5,545	75 %
1994	412	4,123	1,000 %	7,578	5,769	76 %
1995	422	4,308	1,023 %	7,759	6,004	77 %

Note : Total national demand including demand of the Tarija Department.

In Tarija Department, supply will overcome the demand by 8 to 10 times, however, 20 to 30 % of short supply to demand per year will be caused in the nation as a whole. Demand of the wine produced in Tarija Department will be increased in view of the consumption propensity, increase of consumption per capita through the improvement of living standards and the brand name, since the wine produced in Tarija is well-known all over the nation. Cultivated area and production volume neces-

sary to achieve the mentioned wine and liquor production plan: 33 thousand ha of vineyards and 30 thousand production volume will be required.

3.5.7 Agricultural Supporting Services and Organizations

(1) Agricultural experiment, research and extension services

Agricultural experiment, research and extension activities in Tarija Department are performed mainly by the IBTA (Bolivian Agricultural and Stock Breeding Research Corporation). Technical propagation centers are distributed at seven places in the department, and experiment, research, and demonstration farms are distributed at four places (vegetable 1, orchard 3). In the study area, however, no such agricultural experiment and extension centers exist, and only IBTA'S activities are relied on. At present, 51 IBTA experiment, research, and extension members are controlling the overall area in the department, and performing activities for the following purposes mainly for small-scale farm households.

- Development of adequate techniques for improved agricultural income and improved living standard at rural community through improved productivity.
- Extension of experiment and research results and improvement of agricultural techniques.
- Selection the introduced crops suitable for local conditions and preparation of experiment and research programs.

Tarija Department is selected as the area for the priority study program performed by the IBTA regarding corn, wheat, and fruits (grapes, apples, peaches). About 20 km east of the study area, there exists the Grape Cultivation and Testing Center of Tarija Department (Centro Vitivinicola) established by CODETAR with aid from the United Nations. There, grape cultivation experiment is performed at a 20 ha vineyard, and experiment and research of brewing technology is carried out under Spanish technical cooperation.

(2) Agricultural financing

Agricultural financing activities in Tarija Department are made mainly by the Bolivian Agricultural Bank (BAB) and the CODETAR Agricultural Financing Association (UCF). UCF's financing, based on the U.S. aid (U.S. Aid and PL 480 Act), is extended mainly to the agricultural processing industry. Financing to ordinary farmers is performed by the BAB (Tarija Branch). The conditions of financing by the BAB such as objectives and method of loan are as follows.

Objectives of loan and financing method a. annual crops : agricultural management fund b. perennial crops: investment fund (Vineyard and orchard) c. stockbreeding : investment fund d. agricultural equipment and machinery : investment fund	
Conditions of loan	: land ownership (registration completed, or certificate of sale and purchase obtained)
Interest rate (September, 1989)	: 13.84% per year (uniform)
Maturity period and method of loan : annual crops ; 1 year : perennial crops; 10 years (Vineyard, orchard) : stockbreeding ; 10 years : agricultural equip. and machinery; 5 years * Repayment should be made every half year or year, but the interest rate remains the same.	
Credit limit	: per farm household: BS 50,000 Agri. Association : BS 1,000,000
Financial resource for loan (Unit: BS thousand) : funds on hand : Central Bolivian Bank (BCB) Total	15,000 2,500 17,500
Number of farm households for loan : ordinary farm households: : Agri. associations and farmers organi.:	4,000 1,000

It is only the farm households specializing in grape production and a small-scale grape-producing farm households in the study area that are using loans of agricultural financing organizations. Very few ordinary farm households are using loans. This is because many households have not completed land ownership registration, and the unstable agricultural management continuing throughout the year prevents farmers from investing.

(3) Farmers' organization

There are three major farmers' organizations in Tarija Department and the study area, and their outline is described below.

a) Agricultural and Farmers' Federation (SFC)

This organization was established after the Agrarian Reform in 1952. One federation (syndicate) is established for each com-

munity (comunidad). It is intended to organize communities in the unit of province.

b) Agricultural Cooperative Association of Tarija Department (CERCAT)

Ten agricultural cooperative associations were established in Tarija Department in 1974. At present, 840 farm households belong to 16 associations.

c) Farmers Integration Association (CDINCA)

This is a farmers' organization established in 1975 mainly for farmers in the Valle Central area. At present, 360 farm households belong to this organization.

A relatively large number of farm households led by the grape-producing farm households in the study area belong to associations of a) and c). Their major purposes of activities are the cooperative purchase of agricultural production materials (fertilizers, agricultural chemicals and etc.), and the cooperative management of irrigation canals and farm roads. For the operation and maintenance works of irrigation canals, in particular, a coordinator (juez de agua) is elected for determination of priority of water use and collection of the water charge.

At the Santa Ana Nueva community in the study area, on the other hand, there is an agricultural cooperative association consisting of 16 farm households and having 7 ha of land in common. In addition, 45 farm households belong to the Agricultural Congress of Tarija Department (Camara Agropecuaria y Asociaciones de Productores). Various producers associations of wine brewing, fruit and vegetable production, and the dairy industry in Tarija Department joined the Agricultural Congress in 1986 at its establishment for the purpose of developing the agricultural product market and introduced new crops.

3. 6 Irrigation and Drainage

3.6.1 Irrigation and Drainage Facilities

Along Santa Ana River (including its upstream Yesera River) and its tributaries in the study area, the irrigation canals are prepared by individual farm households or several farm households in common. The present canal networks in the study area is shown in Table 3.6.1. Water is introduced into the canal by means of diversion channel under the river bed or by a simple weir using rocks on the river bed. Some farm households specializing in grape production utilize trapezoidal canal with concrete lining. Almost all of the others are unlined earth canals of 40 - 70 cm in width and height, since they run through steep slopes

along the river. No special facility is prepared for diversion of water from the canal to each field. Water is conducted through holes directly made on the canal slope.

Almost all of the existing irrigation canals are utilized only during the rainy season when surface run-off appears in Santa Ana River. At the irrigation network located in downstream part where San Agustin River flows into Santa Ana River, underflow of the river course is utilized by gravitational flow-down or by pumping up. This irrigation water is utilized mainly for orchard and perennial crops, and the quantity is limited.

In the study area, there are vineyards for enterprise farm households that are producing and selling wines and distilled liquors under the brand names CASA REAL and KOHLBERG. The irrigation facilities for these farm households are the same as the said irrigation canal networks in intake and conducting methods, but the former have three to four small reservoirs with capacity of about 2,000 m^3 at the end of the irrigation canal to store the water during the rainy season. In the dry season, underflow water is pumped up, and groundwater is also utilized for irrigation. Except the cultivated lands along Santa Ana River, cultivated lands are scattered along small steams (Quebrada) developed in the study area, and run-off due to rainfall during the rainy season is directly introduced to the fields from Quebrada and utilized. At the cultivated lands spreading over hills and plateau, farming which depends on rainfed is under management.

Many of the present cultivated lands are of sandy soil. In the cultivated lands along Santa Ana River with equipped irrigation facilities, the soil is composed of river deposits with good permeability. Therefore, no particular drainage facilities are required in the cultivated lands in the study area, and no drainage canals are available.

3.6.2 Irrigation Method

Ordinary farmers utilizing the present irrigation facilities adopt furrow irrigation. For planting potatoes, corn, wheat, and vegetables, irrigation is made according to the content of soil moisture every 7 - 10 days when rainfall is not available. Farmers specializing in grape production mainly adopts the drip irrigation with hoses (made in Israel), and also adopt the furrow irrigation in parallel on flat farmlands. Irrigation in these areas is operated according to the growing period and the content of soil moisture. Advanced irrigation utilizing a micro-computer for water supply to the field is also carried out.

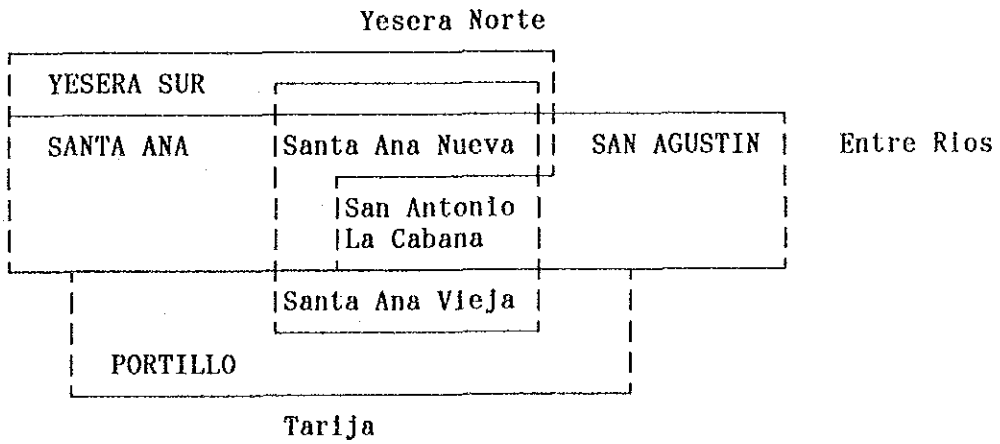
3.6.3 Operation and Maintenance of Irrigation Facilities

For the operation and maintenance works of irrigation facilities, the construction of simple weirs at the intake point, the maintenance of head race, the removal of sediment in the irrigation canals, and the repair of damaged parts are carried out by farmers concerned with the irrigation canals. During the irrigation period, the maintenance works of irrigation canals are also carried out in cooperation by the concerned farmers.

3. 7 Rural Infrastructure

3.7.1 General

The Study Area is located in Cercado Province of Tarija Department. The area extends into the four administrative districts : Yesera Sur, Santa Ana, San Agustin and Portillo. The distance from Tarija City (the Capital of Tarija Department) to the study area is about 25 km. The area consists of three communities : Santa Ana Nueva, San Antonio la Cabaña and Santa Ana Vieja. And houses in the area are found clustered along the roads or rivers.



The number of houses and population at each community is as follows:

Community	Houses	Population
Santa Ana Nueva	113	682
San Antonio La Cabaña	62	184
Santa Ana Vieja	29	190
Total	204	1,056

Source : CODETAR,JICA Nov.1989

On the other hand, an index on major social and rural infrastructure in and around the study area and in Bolivia is as follows:

Items	Santa Ana	Cercado	Tarija	Bolivia
a. Land holding (ha)	7	5-7	7-10	7-10
b. Farmer's income (US$1,000)	1.0-1.3	1.5-1.8	1.8-2.0	1.6-3.1
(urban laborer's income)	-	2.8	2.4-2.8	1.6-3.1
c. Road intensity (km/km2)	0.5	1.1	0.8	0.7
d. Diffusion of water works (%)	0	12	11	10
e. Diffusion of electricity (%)	0	10	15	18
f. Diffusion of telephone (%)	0	5	5	7
g. Diffusion of radio (%)	85	87	88	85
h. Diffusion of T.V (%)	15	25	18	20
i. Schooling rate (%)	90	95	92	90
j. Literacy rate (%)	85	88	86	85
k. Doctors per 1,000 hab.	0	1.5	0.5	0.7
l. Teachers per 1,000 hab.	5	7.5	6.6	5.5

Source: National statistics in Bolivia (1985)
Socio-economic development plan in Tarija Department
CODETAR statistical data (1975-1989)
General features of agricultural and forest industries in Bolivia (1980-1983 JICA)
PLAN ANUAL DE OPERATIVO, CODETAR 1989
BOLETIN INFORMATIVO, INE 1989
SANTA ANA PROJECT, JICA-CODETAR 1989

3.7.2 Current Situation of Rural Infrastructure

(1) Roads

According to the information of the Road Corporation (SENAC), roads in Bolivia are divided into the following categories: departmental road (Red Fundamental), provincial road (Red Complementaria) and district road (Red Vecinal).

The main road in the study area is Route 302 (provincial road). and is connected to Route 1 (departmental road) southwest of the area from Tarija to Bermejo. Moreover, this road, connected to Route 9 via Villamontes east of the area, leads to Santa Curz or Yacuiba. On the other hand, the district roads in the area comprise of Route 3050, 3393 and 3394. Route 3050 joins Route 302 at Santa Ana Nueva village to Yesera Norte. Route 3393 links Route 1 and 302. These roads, trunk roads in the area, are not paved with asphalt.

All these trunk roads are arranged in the right bank area of Santa Ana River, therefore, the left bank area has no definite road networks.

Farm roads link the trunk roads to the cultivated land, however, many points in the farm roads are not available for car traffic because of narrow road width and insufficient maintenance works. Construction of the farm road network is obstructed due to undulating topography and the many small streams.

(2) Drinking water supply

Cercado Province including the study area, Tarija City has a water supply system, but only 16 villages in the rural area have a drinking water supply system (in operation:9, under construction:4, scheduled:3). The percentage of existing rural water supply system is only 10% in the rural area.

Right now, no drinking water supply facilities are available in the study area where rivers, streams and private shallow wells are the predominant source of water. But in the dry season, this area is faced with difficulties to get drinking water. To ensure the drinking water, inhabitants in the area dig the shallow well at the river bed such as Santa Ana river and the daily works to draw water is important for the farmer. These factors is one of the obstacles to promote the settling down of the inhabitants in the area.

On the other hand, this area has one public well for drinking water at the Santa Ana Nueva primary school (equipped with manual pump, 7 m depth and no dried up during the dry season), and no well is available in the other villages. Only four private wells are being utilized in the area.

In order to judge the possibility of utilization for drinking water, the water quality analysis is carried out at major points in the study area (river 3, well 2). The results of the water quality is as follows. According to the results of the quality analysis, it is confirmed that materials unsuitable for irrigation use is not contained and well water has no problems for drinking.

Number		No.1	No.2	No.3	No.4	No.5
Location		Rio Yesera	Rio Santa Ana	Santa Ana school well	Rio Santa Ana	San Miguel Well
Date		10.I.90	10.I.90	10.I.90	10.I.90	10.I.90
Temperature	^{o}C	16.7	19.2	19.1	22.5	23.6
Water temperature	^{o}C	19.0	20.0	20.6	23.4	20.9
pH		7.5	7.6	7.1	7.4	7.2
Ec	uS/cm	200	220	510	370	370
BOD	mg/l	18.89	8.99	15.60	18.89	22.19
DO	mg/l	7.37	7.64	1.23	7.47	4.30
SS	mg/l	0.004	0.003	0.004	0.012	0.004
Na+	mg/l	15.74	18.73	21.08	19.27	19.43
K+	mg/l	3.07	3.19	4.83	3.10	3.08
Mn	mg/l	0.19	0.27	2.40	0.30	5.50
Fe	mg/l	0.035	0.025	0.01	0.012	0.015
Ca++	mg/l	58.0	62.0	162.0	100.0	118.0
Mg++	mg/l	42.24	56.14	81.44	75.42	86.06
CO3--	mg/l	53.32	59.42	144.74	102.08	97.51
HCO3-	mg/l	9.29	6.19	N.D	6.19	N.D

to be continued

Number		No.1	No.2	No.3	No.4	No.5
Location		Rio Yesera	Rio Santa Ana	Santa Ana school well	Rio Santa Ana	San Miguel Well
SO4--	mg/l	60.00	54.0	108.0	104.0	65.0
Cl-	mg/l	3.93	4.92	17.70	7.87	8.85
Colon Bacillus	MPN/100ml	10	10	10	10	0
Bacillus	MPN/100ml	1000	1000	1000	1000	1000

Analyzed by: UNIVERSIDAD AUTONOMA "JUAN MISAEL SARACHO"
LABORATORIO BROMATO TECNOLOGIA, TARIJA-BOLIVIA

(3) Electricity

The rural area in Cercado Province, only 12 villages have electric power supply system (seven villages are in operation and five villages are scheduled). The plan of rural electric supply is beginning to materialize, although it will take many years to perfect the electrification in the rural area.

In the study area, the two wineries have electric supply system, but all farmers remain without electricity because the basic power networks are not established in the whole area except for Santa Ana Vieja village. At Santa Ana Vieja village, trunk line for electric power has been installed and electric supply will start in a few years.

(4) Medical facility

The area has one medical center at Santa Ana Nueva, and it was established at 1974. The center is operated by one nurse and doctor is not available. Therefore, the medical activities at the center are mainly designed for prevention, early treatment of diseases, guidance for pregnant women and there is a midwife. The center has two beds where are mainly used for delivering babies. The users who are mainly made up of babies, children and pregnant women, are about 20 people per month.

The main diseases are diarrhea, bronchitis, smallpox, malnutrition, malaria and chagas (an endemic disease caused by a parasitic insect with high mortality). The problems of the center are the lack of medicines and facilities for treatment because of the lack of funds, and patients must be transferred to hospitals or medical centers in Tarija City for serious treatment. But emergency organization and facilities for medical care are not well-equipped, moreover the center has not any communication facilities such as telephone or wireless telephone.

The other two villages have no medical center, therefore patients must be taken to medical centers or hospitals in Tarija City.

(5) Education

As for education facilities in the study area, the main school is

located in Santa Ana Nueva consisting of a kindergarten (two years), a primary school (five years) and junior high-school (three years). The branch school, located in San Antonio and Santa Ana Vieja, has a kindergarten and a primary school.

In Bolivia, there is no compulsory education system, but schooling rate is about 100 %, and literacy rate is over 85 %. In the rural area, the rate of students taking upper education is low, junior high school is 45% and high school decreases to 6%.

(6) Communication

In the area, communication facilities such as telephone do not exist. Therefore, a few residents have private radio telephone systems. A telephone station of ENTEL is located in Tarija City. Long distance and overseas calls can be made through the operator.

The postal service office is located in Tarija City. The post office is responsible for receiving and sending mail, but the home delivery service only exist in Tarija City, and residents in the rural area must go to the post office to get their mail.

(7) Processing of sewage and drain-water

In the study area, few families have a toilet facilities, and their sewage is generally discharged directly into the river or stream or into the earth. Tarija City has a sewage system, but treatment facilities is still under construction. Therefore, untreated drain-water is discharged directly into the river.

(8) Agricultural facility

Within the study area, there are no agricultural-related facilities such as collecting/shipping center, agricultural extension center or a meeting place. There is some organization by the farmers along the area of Santa Ana river, some unions for operation, maintenance and control of irrigation water, and the agricultural cooperative union in Santa Ana nueva is organized with 16 farmers who have 7 hectare farmland.

(9) Other facilities

Living condition of the farmers in the study area are as follows;

Family : Parent, a couple and their children (3 or 4)
A family has 5 to 7 people

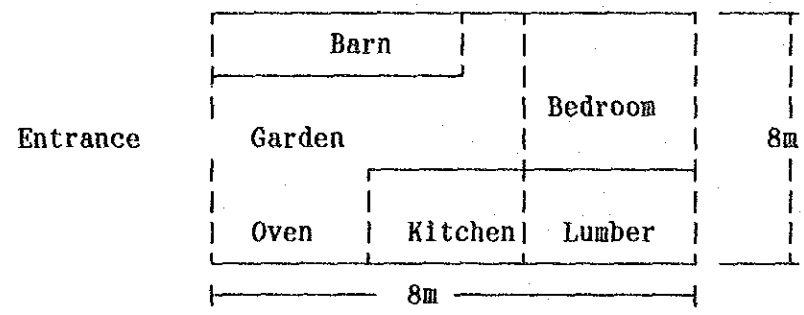
House : Wall material is made of sun-dried brick without any protection
Roof material is straw-thatched or unglazed tile.

Room : Each farmer has 2 or 3 rooms such as a bedroom, kitchen and barn. Each room stands alone.

Place rooms: There is a garden in the center of the house area and the bedroom, kitchen, barn and oven are built around it. Each room is made of stone or adobe walls.

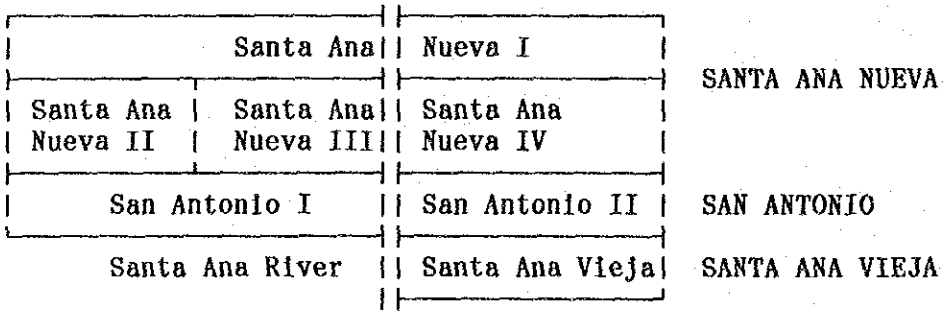
Toilet : No facility

The standard housing plan of the farmer is as follows:



3.7.3 Assessment of Present Conditions

As assessment of present conditions, the study area is divided into 7 sectors to distinguish the features of the area.



The following shows the present conditions in each sector:

sector	Santa Ana Nueva				San Antonio		Santa Ana Vieja
Facility	I	II	III	IV	I	II	
1.Farmer	11	20	41	41	34	28	29
2.Departmental Road	---	○	○	---	---	---	---
3.Provincial Road	▲	---	○	---	▲	---	▲
4.District Road	▲	▲	▲	▲	▲	▲	▲
5.Water supply	---	---	▲	---	---	---	---
6.Electricity	---	---	▲	---	▲	---	---
7.Medical care	---	---	▲	---	---	---	---
8.Kindergarten	---	---	○	---	---	▲	▲
9.Elementary school	---	---	○	---	---	▲	▲
10.Junior high school	---	---	○	---	---	---	---
11.Telecommunication	---	---	---	---	---	---	---
12.Irrigation system	---	---	▲	▲	▲	▲	---
13.Agriculture related	---	---	▲	---	---	---	---

◎:High Level ○:Medium Level ▲:Low Level ---:No Facility

As in the study area, the present improvement of rural infrastructure is very low on the whole. Within the area, Santa Ana Nueva III is a sector that has the most rural infrastructure facilities are accumulated. But this sector has only some facilities such as a trunk road, education and medical facilities, the condition of the basic infrastructure among other sectors is not much different.

The problems of the present conditions in each sector are as follows:

a.Santa Ana Nueva I :The sector locates the most upstream reaches of the area, and lags behind the improvement of infrastructure facilities. Therefore, the problems in this sector are improvement of basic facilities such as village roads, irrigation and drinking water supply.

b.Santa Ana Nueva II :This sector is clustered along Route 302. Therefore, this sector has no problem such as main transportation. But some points in the farm roads are not available for car traffic. Summary of the problems in this sector are as follows: rehabilitation of farm roads, stable irrigation and drinking water supply for dry season.

c.Santa Ana Nueva III:Within the study area, this sector has the most infrastructure facilities. Accordingly, this sector is located as the core of the area. And this sector must be improved in both quality and quantity of

social infrastructures. To summarize, the following improvements should be made: improved irrigation and medical facilities, establishment of power networks and wireless telephone and establishing road networks between other sectors.

d.Santa Ana Nueva IV :This sector is located on the left bank of Santa Ana river. This sector does not have any basic infrastructures. Therefore, the following points should be considered: establishment of road networks and improvement of stable irrigation and drinking water supply systems.

e.San Antonio I :Basic infrastructures in this sector have been improved to a certain extent like Santa Ana Nueva III. This sector should be considered to raise the quality of the present facilities. It is one urgent problem in this sector to improve its irrigation system.

f.San Antonio II :This sector is located in the left bank of Santa Ana river like Santa Ana Nueva III. But this sector is closely united and there is the branch school for primary education. And then, this sector would be taken the place of sub-center in the area. Therefore, this sector must be improved in both quality and quantity of its social infrastructures. The following points should be considered: enhancement of education facilities, establishment of power network and the establishment of a medical center.

g.Santa Ana Vieja :This sector is located in the left bank area of Santa Ana river, and its traffic condition is very good because the sector is close to Route 1, and it has a high potential capacity for improvement. Accordingly, the following improvements are required: improvement of stable irrigation and drinking water supply system, establishment of power network and improvement of rural road networks to other sectors.

3.7.4 Problems for Improvement

In the area, basic infrastructure should be improved in order to promote the settlement of the farmer in the area and to establish stable agricultural activity. However, drastic improvement of rural infrastructure facilities when the sector is not ready to accept these facilities would disorder the sector, and improved facilities would not be made the best of.

Therefore, improvement program on a stage-wise basis must be established taking the quality and quantity of the improvement into account. The sector, where social infrastructure facilities are already to be found should be obliged to improve the quality of its facilities. And the major items to be improved in the other sector, where the facilities have not been improved, basic infrastructures should be installed in quantity.

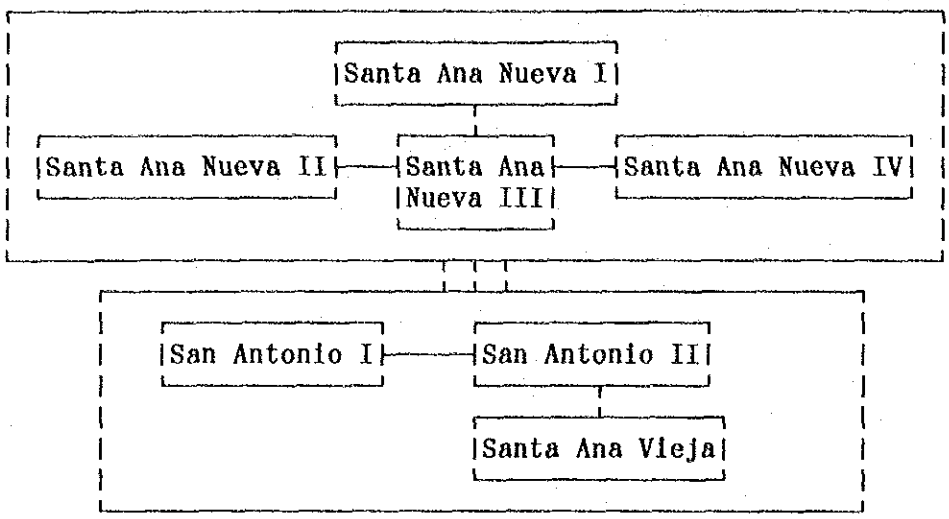
According to the above-mentioned and result of the assessment of the existing situation, problems for improvement on the area are shown as follows:

a. To be secured in quantity: Santa Ana Nueva I and IV
b. To improve in quality : Santa Ana Nueva II San Antonio I
Santa Ana vieja
c. Both quality and quantity: Santa Ana Nueva III San antonio II

The following is the major items to be improved :

a. To secure on quantity : Establishing of farm road networks.
Stable irrigation and drinking water supply.
b. To improve in quality : Dissolution of impassable sections of farm roads.
Establishing irrigation system.
Improvement of electric power.
c. Both quality and quantity: Improvement of road networks.
Enhancement of medical and education facilities.
Establishing drinking and irrigation water systems.
Improvement of electric power.

To clear up the functional assignment of each sector in the area, Santa Ana Nueva III is located as the center sector in the area and San Antonio II is as the sub-center sector. From the above, the functional assignment of each sector in the area is composed as follows.



3. 8 Problems resulting from the present Conditions and Items to be Improved

The following factors, arising from the natural and social conditions in the area, will be pointed out to obstruct the development in the area.

- The insufficient amount of precipitation in the area (450 mm/year within the area), and the resultant sharp decrease of run-off discharge in the river during the dry season.

- The lack of easily tillable flat land because of the undulating topography, and the difficulty of irrigation on the terraces area.

- The progress of erosion, which is caused by such factors as the geological features of the strata (which is composed of thick lacustrine and/or fluviatile deposits in the Quaternary period), the sparse vegetation (mainly a result of too much grazing by cattle), and the poor maintenance of arable land (because of its sporadic location).

- The small scale of farming units (a result of the above natural conditions) and the low income of farmers (due to the low level of agricultural productivity).

- The insufficient infrastructure and means of production, resulting from the low income of the inhabitants in the area.

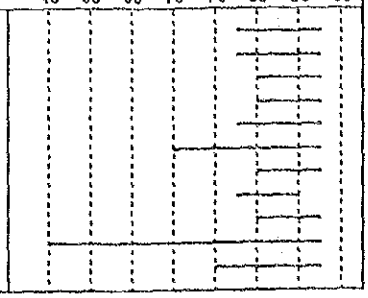
- The conservative style of farming, caused by the passive nature of farmer organization and the slow diffusion of new farming technique and knowledge.

Therefore, in order that the area may be independent as an agricultural community in the Valle Central region and play a part in the source of supplying agricultural products to the region, the factors which impede development of the area will be eliminated. Furthermore, the improvement plan that the area will develop as a vital rural community in accompany with increasing agricultural production, is required.

For the contents of the project to be improved from the present conditions in the area, the establishment of the agricultural development plan of water resources at its core, and the establishment of the improvement plan of living environment making a pair with a improvement of agricultural producing base are the principal of the development plan in the objective area.

Table 3.2.1 Summary of Meteorological and Hydrological Station

Station	Location S.L	Location W.L	Elev.	Content CO	Tp	P	E	L	Observation Period
1. ALTO CAJAS	21°18'	64°28'	2,440			●			1977~1988
2. YESERA NORTE	21°21'	64°33'	2,320			●			1976~1988
3. SAN PEDRO B.V	21°26'	64°40'	2,195			●			1979~1988
4. GAMONEDA	21°30'	64°37'	2,155			●			1979~1988
5. SANTA ANA	21°31'	64°34'	1,935			●		●	1977~1988
6. JUNACAS	21°26'	64°27'	2,370		●				1969~1988
7. SAN AGUSTIN NORTE	21°30'	64°49'	2,120			●			1979~1988
8. LA CABANA	21°34'	64°36'	1,870			●			1976~1985
9. LADERA CENTRO	21°39'	64°32'	2,080			●			1979~1988
10. TARIJA-AASANA	21°33'	64°43'	1,860	●					1946~1988
11. EL TEJAR UNI.	21°32'	64°43'	1,851	●					1975~1988



CO: General Meteorological Station
TP: Self-recrding Rain Gauge Station
P : Rain Gauge Station
E : Evaporation Gauge Station
L : Self-recording Water Gauge Station

Table 3.2.2 Rainfall in the Study area and its surounding area

(UNIT: mm)

Station	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
ALTO CAJAS	181.4	187.9	90.6	48.1	4.8	4.2	2.4	6.4	5.2	22.2	77.3	87.4	549.7
YESERA NORTE	145.2	145.2	122.5	42.8	4.5	2.1	2.5	7.8	8.6	36.2	83.0	135.9	736.3
SAN PEDRO B.V	122.0	98.4	87.8	24.5	2.0	1.2	1.6	5.6	5.2	23.0	56.0	112.9	540.2
GAMONEDA	127.3	104.3	72.1	28.7	4.2	1.4	1.7	5.4	5.4	21.5	58.6	97.7	528.3
SANTA ANA	118.6	74.4	55.8	18.9	4.0	0.6	0.6	3.2	2.1	23.2	46.4	107.8	455.7
JUNACAS	167.2	128.5	92.5	29.6	1.3	5.0	1.9	6.9	8.2	26.4	67.4	98.8	633.8
SAN AGUSTIN N.	71.8	52.1	37.1	28.5	3.2	0.9	0.9	3.4	3.4	16.9	29.9	61.6	389.7
LADERA CENTRO	91.3	82.2	67.6	19.9	0.4	0.0	0.0	3.4	5.8	14.7	36.8	87.3	413.9
LA CABANA	116.5	88.6	48.3	18.8	2.4	2.0	0.9	5.6	9.3	33.1	53.1	99.8	462.5
Areal Ranfall	132.4	121.2	99.0	36.2	4.1	2.3	2.0	6.6	7.0	30.1	69.2	117.3	627.4
EL TEJAR UNI.	137.7	116.4	79.7	31.7	2.2	0.6	2.4	4.9	2.6	34.2	83.2	152.9	649.1
TARIJA-AASANA	142.8	129.5	75.5	23.6	2.7	0.9	0.7	2.6	6.7	32.7	65.8	126.0	609.5

Note: Areal rainfall was estimated by Thiesen Method using the rainfall of 7 gauging stations which represent the rainfall of the basin (248.79 km²) at the Santa Ana Gauging station.

Table 3.2.3 Monthly Mean Discharge of the Santa Ana River (at Santa Ana Gauging Station) (D.A = 248.79 Km2)

(Unit: m3/s)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL (MCM)	Rain (mm)	R. Co. (%)
1977	2.189	0.278	1.378	0.656	0.328	0.235	0.049	0.000	0.026	0.011	0.036	0.624	15.170	630.1	9.7
1978	0.653	5.741	0.452	0.569	0.247	0.275	0.078	0.000	0.000	0.005	0.147	1.136	23.342	642.0	14.6
1979	3.232	1.511	2.214	0.247	0.159	0.109	0.095	0.019	0.002	0.155	0.141	1.741	25.347	668.6	15.2
1980	2.235	1.284	1.140	0.861	0.315	0.032	0.013	0.005	0.036	0.096	0.041	0.039	16.085	489.7	13.2
1981	2.864	3.558	0.915	0.629	0.085	0.045	0.025	0.010	0.001	0.007	0.158	0.326	22.082	726.1	12.2
1982	1.126	0.713	1.919	0.566	0.111	0.032	0.010	0.000	0.000	0.029	0.029	0.523	13.437	581.5	9.3
1983	0.263	0.418	0.008	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.169	0.124	2.544	332.1	3.1
1984	3.627	0.651	3.208	0.969	0.327	0.066	0.000	0.065	0.000	0.119	0.214	0.494	25.868	849.4	12.2
1985	1.448	3.882	2.908	0.669	0.051	0.101	0.003	0.029	0.033	0.024	0.293	0.898	21.224	662.1	12.9
1986	1.015	4.190	2.059	0.878	0.006	0.076	0.045	0.000	0.003	0.011	0.332	2.090	27.474	698.1	15.8
1987	2.993	1.363	0.401	0.286	0.060	0.016	0.003	0.000	0.000	0.000	0.758	1.923	20.406	509.4	16.1
1988	3.112	3.514	3.774	1.713	0.228	0.115	0.073	0.042	0.011	0.000	0.624	1.552	38.798	738.7	21.1
MEAN	2.055	2.258	1.532	0.671	0.159	0.092	0.033	0.014	0.009	0.038	0.249	0.956	20.974	627.3	13.4

Table 3.4.1 Soil Classification

Order	Sub-order	Group	Sub-group	Family	Series	Area [1] ha	Area [1] %
Entisols	Fluvents	Ustifluvents	Typic Ustifluvents	Coarse loamy, Illitic, Thermic	Santa Ana	250	7.8
					Sub-total	250	7.8
Inceptisols	Ochrepts	Ustochrepts	Fluventic Ustochrepts	Loamy, Illitic, Thermic	Cerro	269	8.4
					Sub-total	269	8.4
Dridisols	Orthids	Camborthids	Typic Camborthids	Coarse loamy, Illitic, Thermic	Molino	279	8.7
					Ruiz	281	8.8
		Durorthids	Entic Durorthids	Sandy, Illitic, Thermic	La Cruz	662	20.6
					Bajial	522	16.3
		Calciorthids	Typic Calciorthids		La Pintada	585	18.2
					San Agustin	117	3.6
					Caldera Chico	242	7.6
					Sub-total	2,688	83.8
					Total	3,207	100.0

Note : [1] Except basin area, gully and where exist base-rock explode of 4,386 ha.

Table 3.6.1 Inventary of the Present Irrigation System

No.	Location	Irrigated Area (ha)			Related	Canal	
		Total	Rainy	Dry	Farmers	Length(m)	Structure
1	Yeaera	0.6	0.6	-	2	560	earth
2	Sta. Ana Nueva	9.3	9.3	-	4	2,120	"
3	"	0.4	0.4	-	2	280	"
4	"	13.9	10.2	3.7	8	2,242	"
5	"	3.8	3.8	-	3	1,400	"
6	"	6.8	4.9	1.9	5	1,180	"
7	"	24.9	24.9	-	15	4,033	"
8	"	30.6	30.6	-	30	3,209	"
9	"	53.4	53.4		15	4,665	earth & concrete
10	S. Antonio	52.6	52.7	0.9	11	2,690	earth
11	La Cabana	39.7	36.0	3.7	41	5,100	"
12	"	25.1	25.1	-	3	1,100	"
13	"	2.6	2.6	-	1	460	"
14	"	2.0	-	2.0	1	470	"
15	Sta. Ana Vieja	17.5	17.5	-	5	300	"
16	"	8.3	8.3	-	7	610	"
17	"	9.9	9.9	-	12	160	"
18	S. Agustin Sud	2.2	2.2	-	5	600	"
19	"	7.1	7.1	-	10	650	"
20	San Antonio	5.3	5.3	-	5	1,450	"

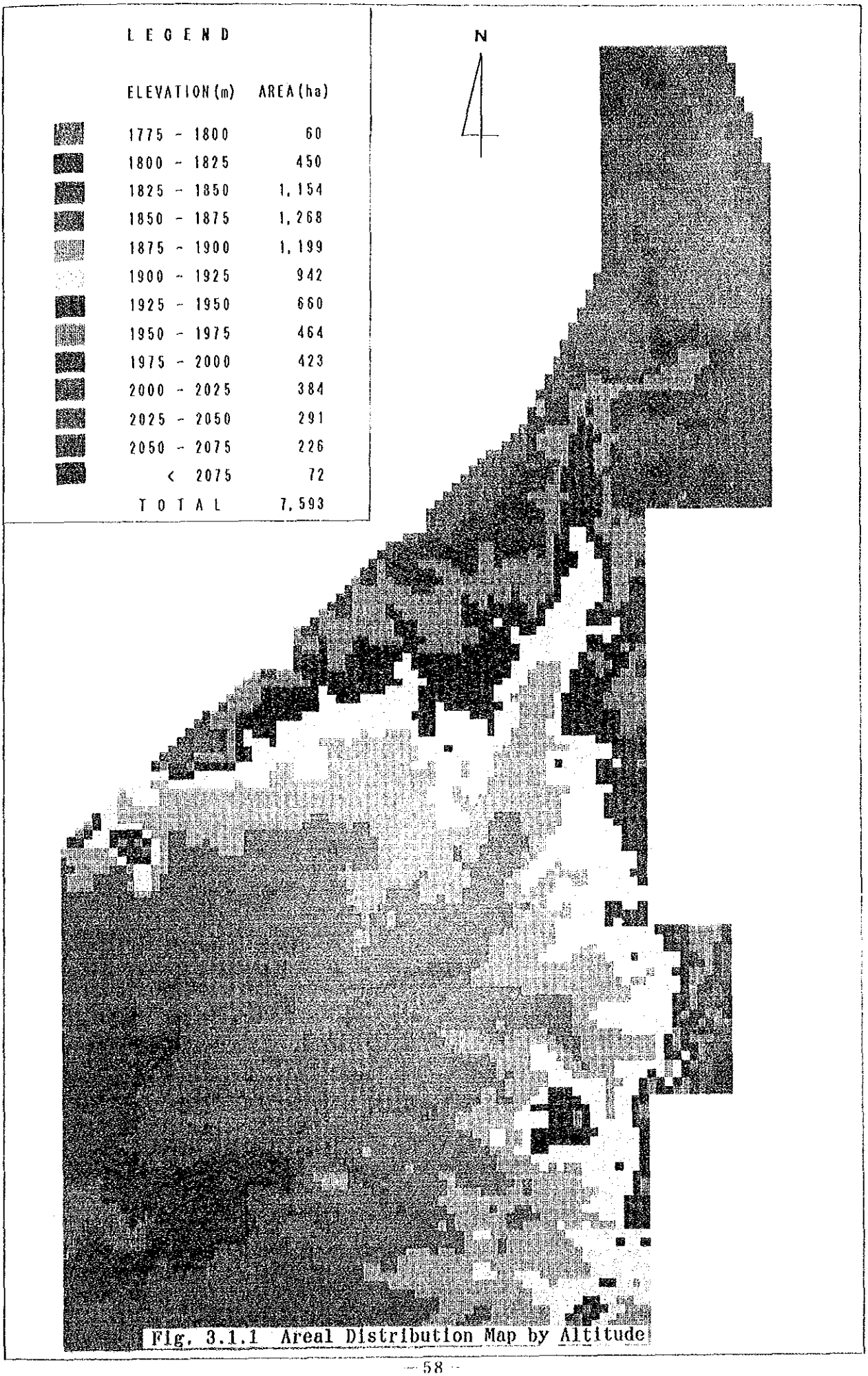


Fig. 3.1.1 Areal Distribution Map by Altitude

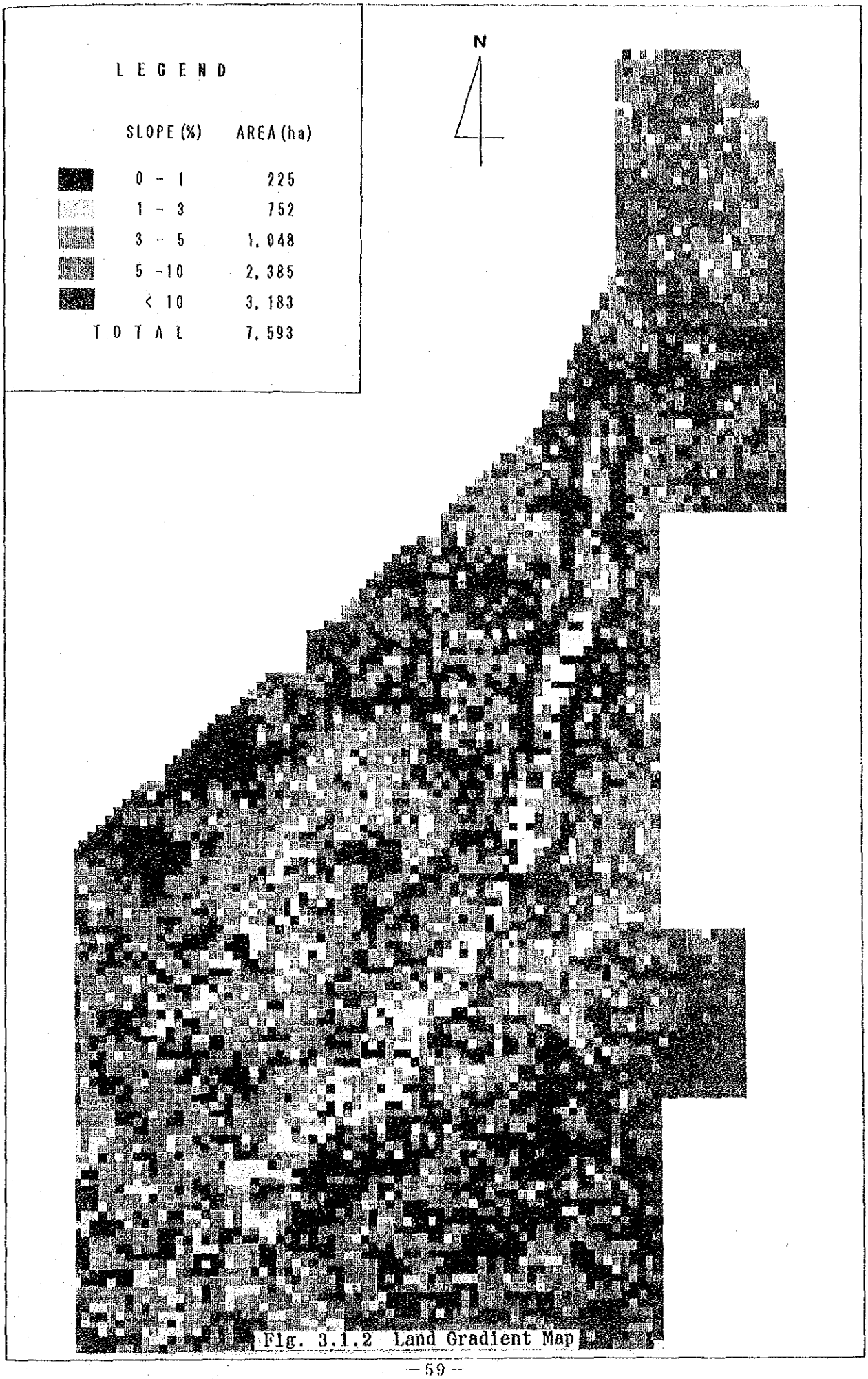


Fig. 3.1.2 Land Gradient Map

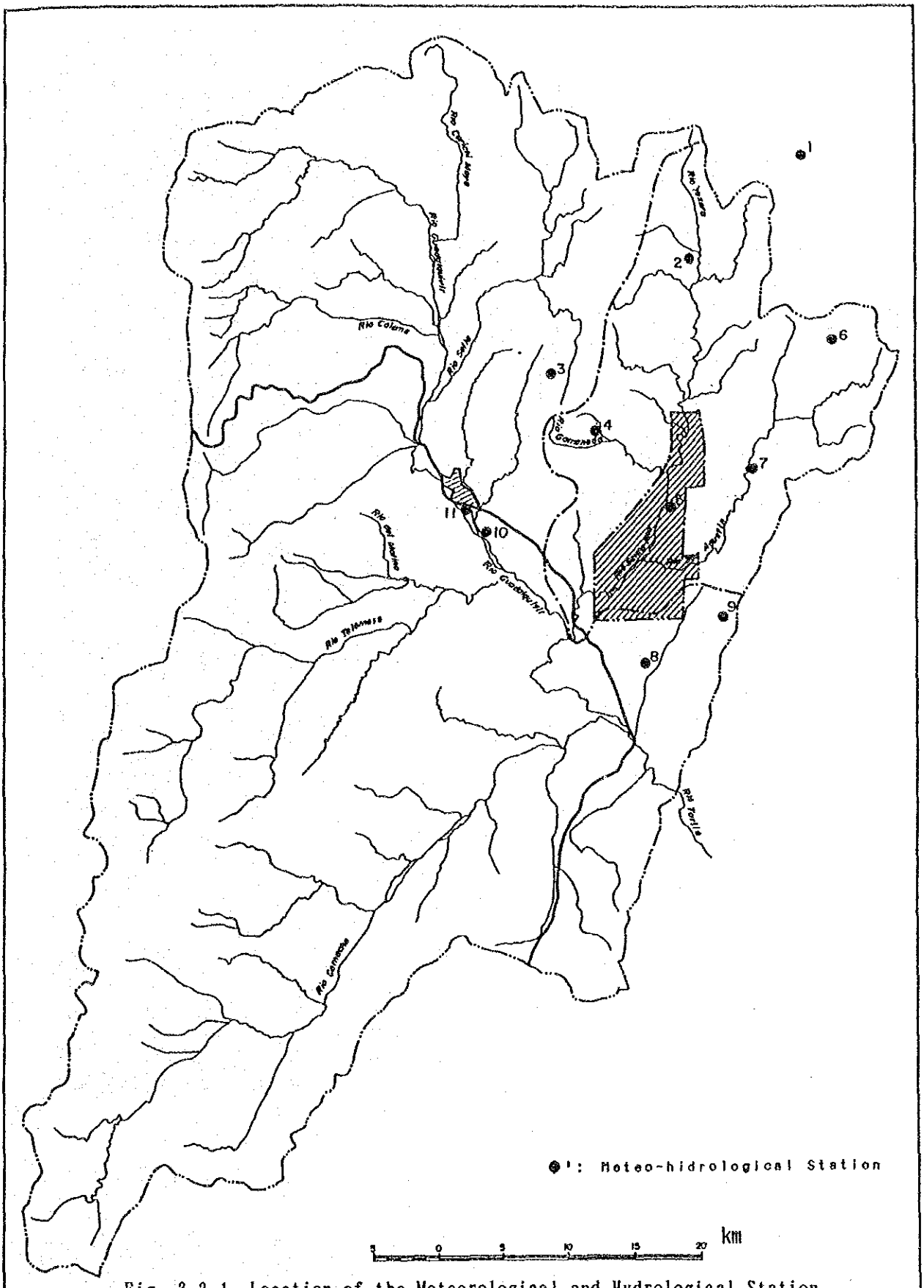


Fig. 3.2.1 Location of the Meteorological and Hydrological Station in the Santa Ana Basin

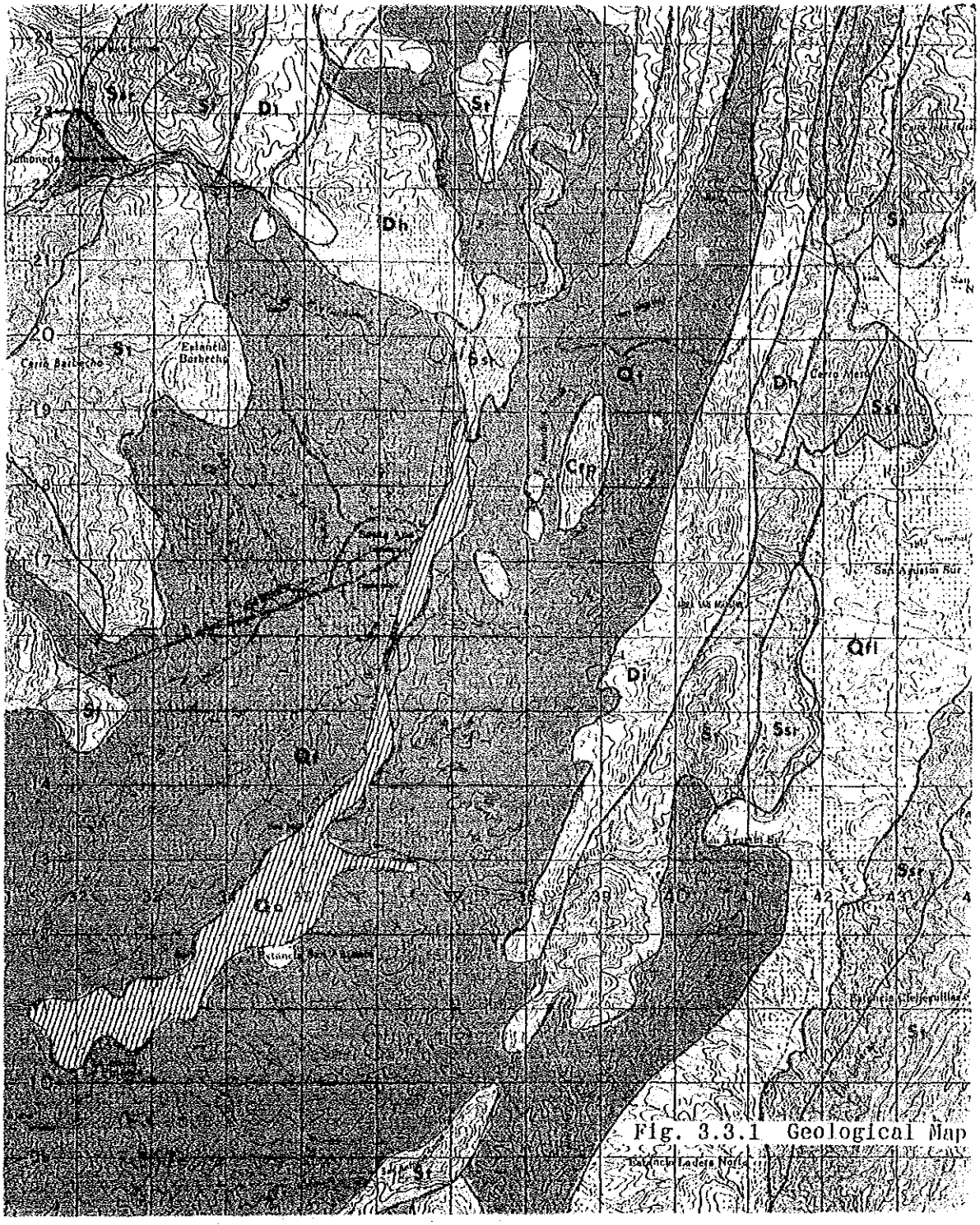


Fig. 3.3.1 Geological Map

L E G E N D

Qa	Alluvium: sand and gravel layers	Dl	Devonian: muddy and mica stone with fossils
Qfl	Diluvium: sand layer and sandy mud layer	Dh	Devonian: sandy stone with thin muddy stone
Qt	Diluvium: fluvial and lacustrine terrace sand and gravel layers	St	Silurian: dark green sandstone, fine mica sandstone and mudstone
Crp	Carboniferous: gravel bottomset bed layer with sandy stone	Ssr	Silurian: sandy and muddy stone

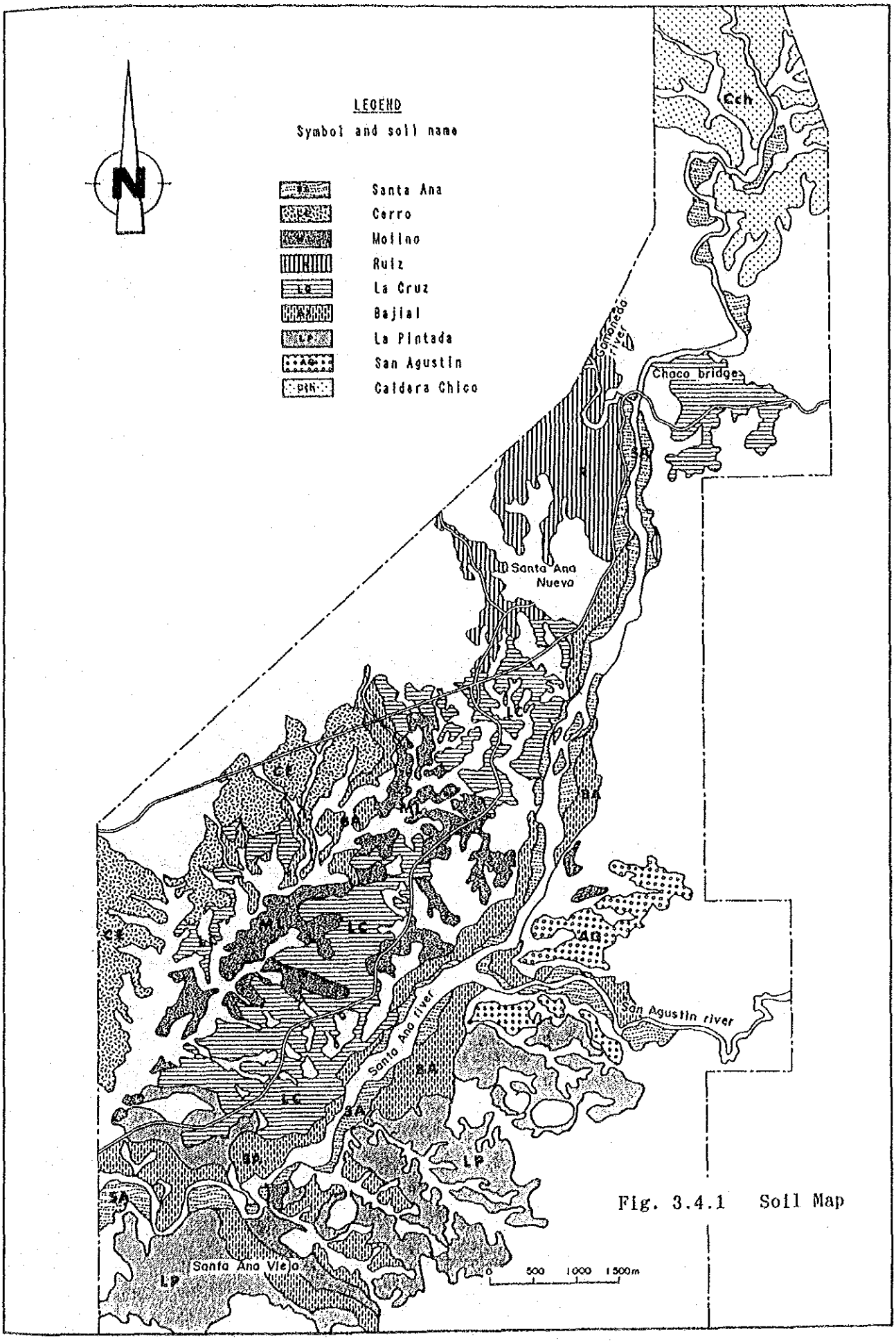


Fig. 3.4.1 Soil Map

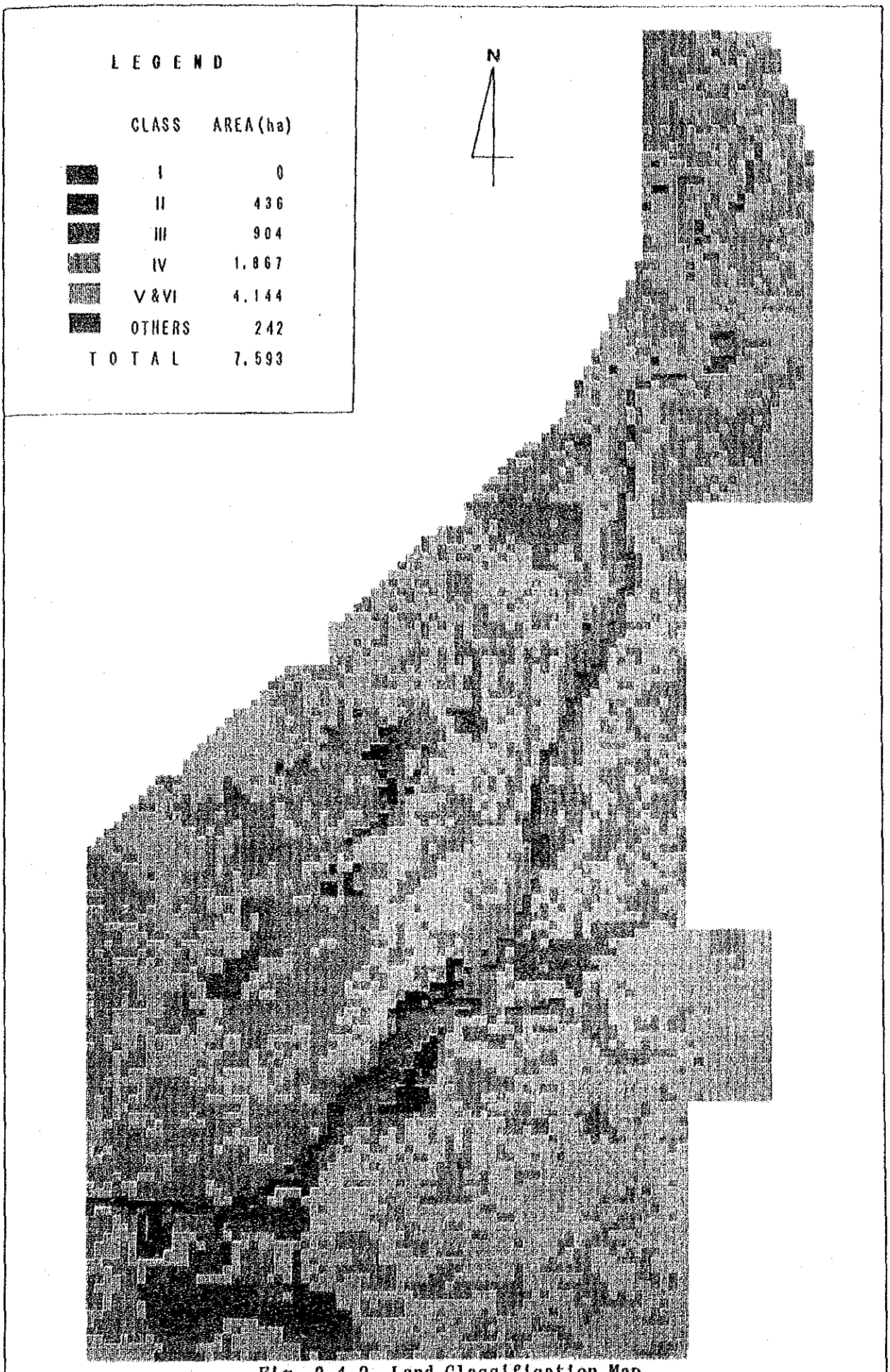


Fig. 3.4.2 Land Classification Map

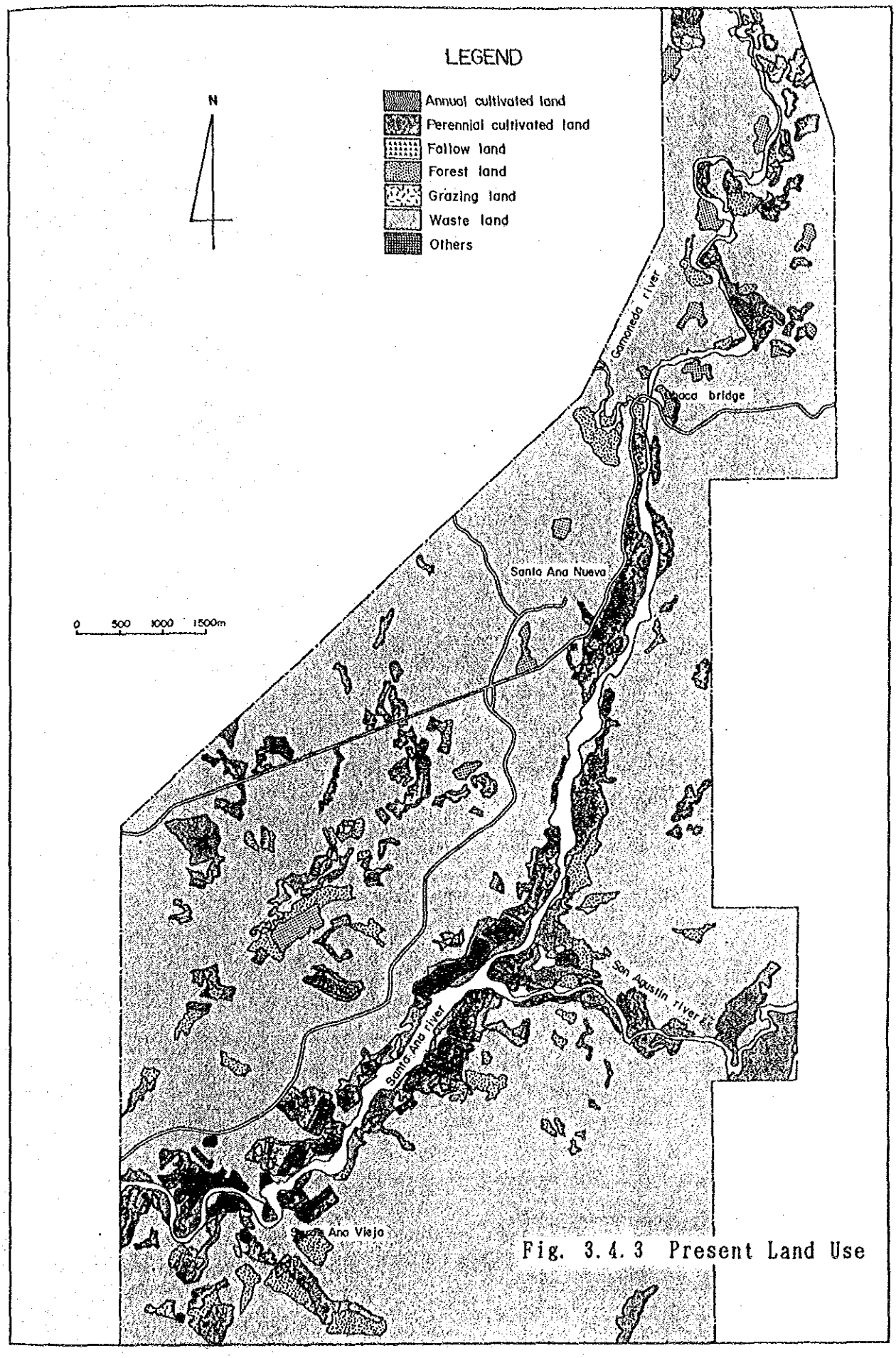


Fig. 3.4.3 Present Land Use

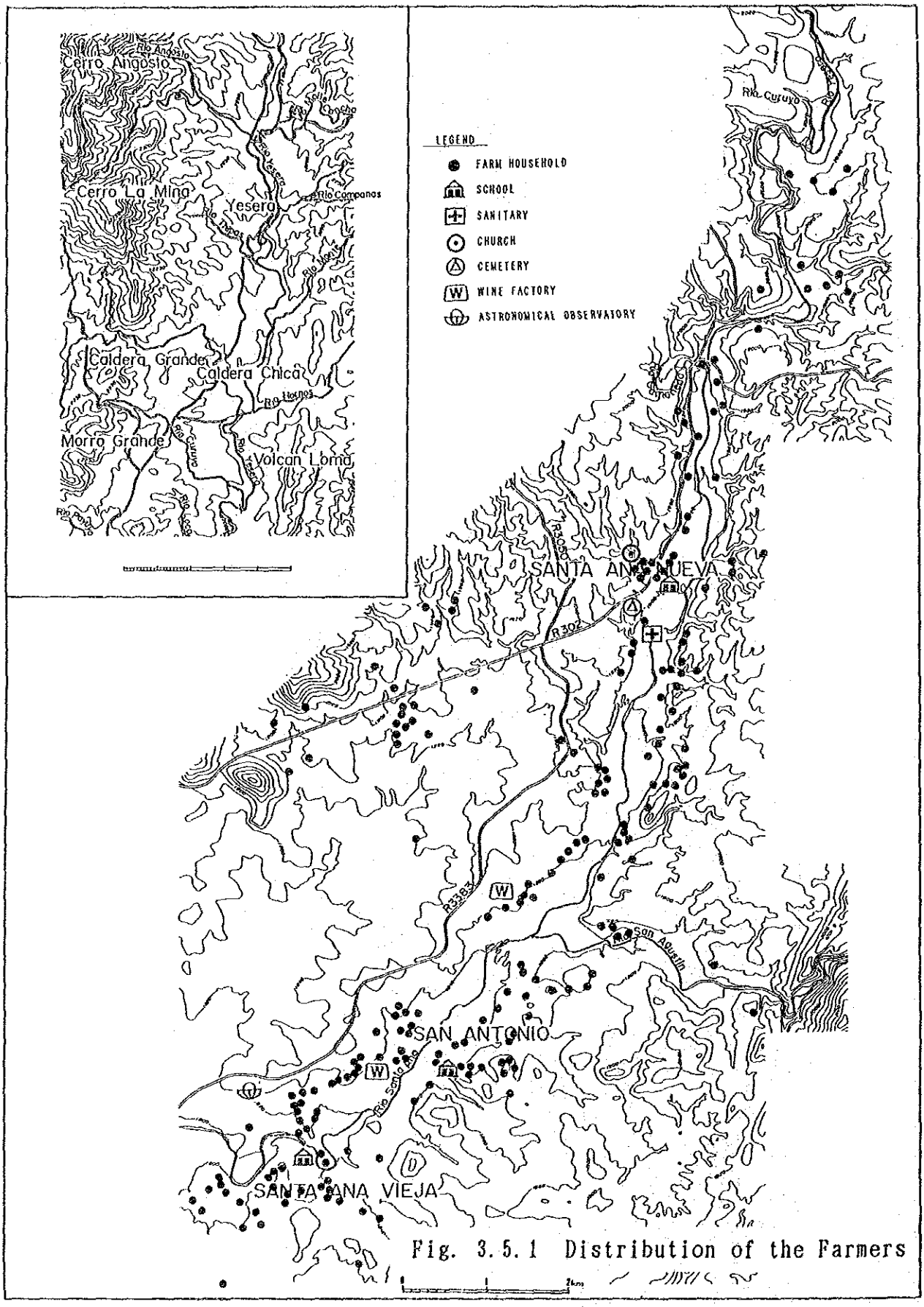
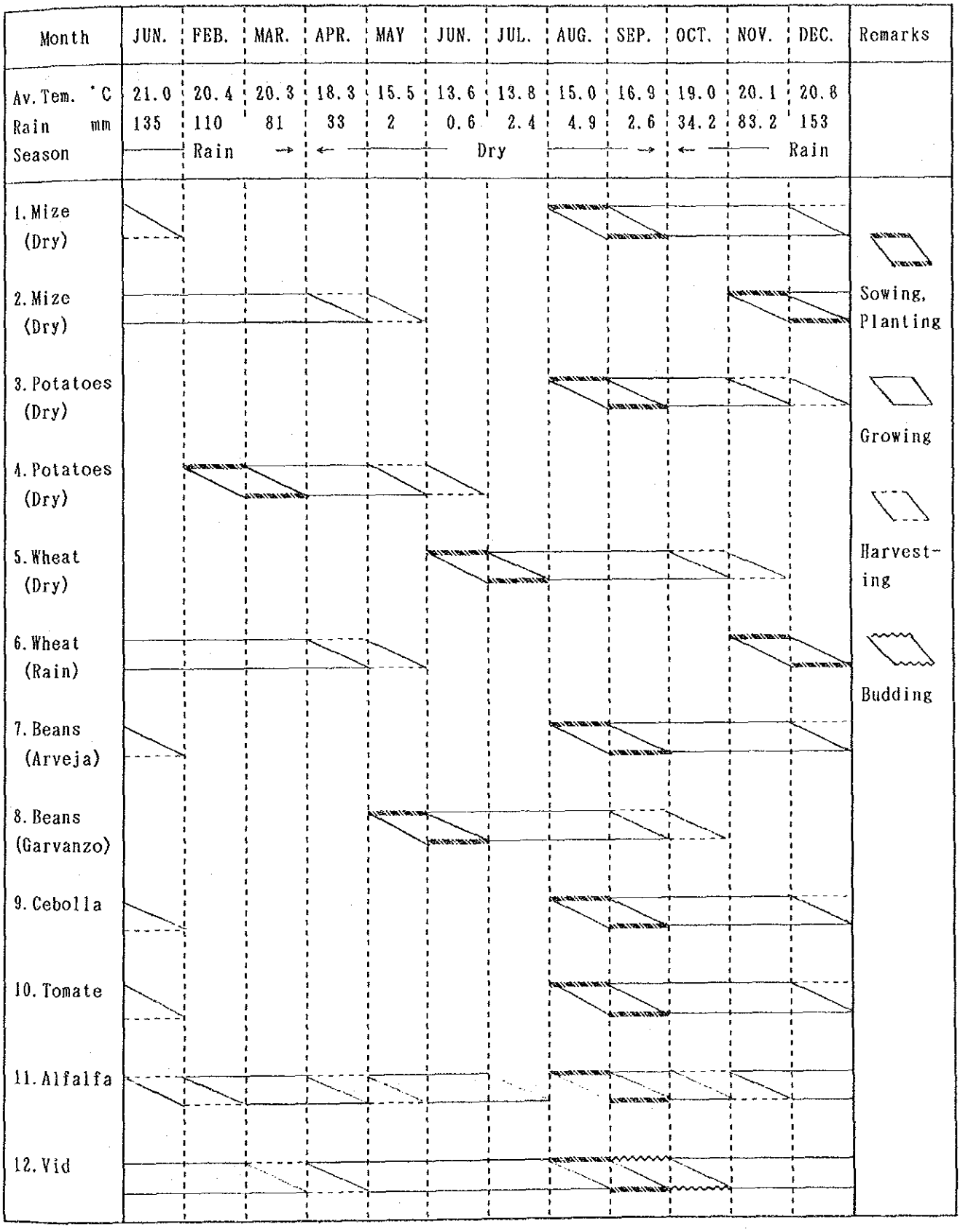


Fig. 3.5.1 Distribution of the Farmers

Fig. 3.5.2 Present Cropping Calendar



CHAPTER 4 THE DEVELOPMENT SCHEME

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4. 1 Basic Concept

4.1.1 Positioning of the Project and the Objective Area

The Valle Central region in Tarija Department, which includes the the project area, can be pointed out not only for the similarity of topography, climate, and other natural conditions throughout the region, but also for the various problems regarding the agricultural development and the promotion of rural areas that the whole region has in common. These problems include the small scale of farming by each farm household, the chronic water shortage during the dry season, and the undeveloped infrastructure in the rural communities. The water shortage during the dry season in the area is the most severe in the Valle Central region. The small-scale farmers rely mainly on the cultivation which depends on the rainfall during the rainy season. During the dry season, when cultivation is difficult due to a water shortage, going abroad and working in non-agrarian jobs has become a way of life. As a result, more than 60% of the farm income is earned through means other non-agricultural income besides farming, and this ratio is increasing yearly. A striking result of this reliance by farmers on both farming and non-agrarian jobs for their income has been that hitherto independent farmers have sold their land and been forced to become tenant farmers of agrarian workers. In some cases, they have even had to give up farming entirely.

In addition, the increase in population, which has been going on since the latter half of the 1970s (more than 3.5%/year), has accelerated the division of arable land held by farmer has also resulted in a decrease in their income due to greater consumption by the families of their own farm produce. These factors have helped to bring about the shrinkage of farm management. On the other hand, medium-scale or large-scale farmers, which unlike small-scale farmers have irrigation facilities and are capable of cultivation throughout the year, by specializing in the cultivation of agricultural commodities, mainly fruit and vegetables, have been able to realize a profitable manner of farming because the products are easily turned to cash. This has resulted in the creation of different social classes among farmers of the same area.

More than 60% of the agricultural products produced in the country come from small-scale farmers, 70% of which are distributed in the mountainous and mid-mountainous areas, mainly in the mid-slope of Andes. Since these areas suffer from the same limitations regarding agricultural production that plague the Valle Central region (which were discussed above), measures that would overcome problems associated with small-scale farming and raise the productivity of farming units are given top priority both as part of the project for national development and as part of the measures for the development of national agriculture.

From the above, it is clear that the natural and social conditions that are prevalent in the Valle Central region also apply to the rural areas throughout the mountainous regions of Bolivia. Therefore, the plans that are formulated for the development of agriculture and rural community for the area under consideration, and the process of their realization, would benefit not only for the objective area. The know-now and methods developed in the process will also be helpful in the development of projects for similar areas in other mountainous areas of Bolivia.

4.1.2 Required Conditions of the Development Projects

As previously mentioned, the area for which the project is planned has severe natural conditions, such as climate and soils in the whole Valle Central region. In addition, due to its relative inaccessibility to the markets, the development and the improvement of infrastructure for the agricultural production and the rural environment have lagged behind. However, because of a number of characteristics, which are listed below, the potential for the development of agriculture in the area is considered to be high. This would entail a unified development of the region along with a development of the rural areas, through the improvement and the development of agricultural production and the rural environment.

- The area located on the outskirts of the city, about 25 km from Tarija city, which is the largest market for agricultural products in the department.
- The area has the merit of being suitable for the production of a profitable kind of grape in the department.
- The method of farming by the farmers in the area under consideration is similar, making projects for the improvement of farm management and farm production easier to implement.
- The existing farmer's organizations are well established, separately for each community.
- Full-scale facilities are not yet in place, and their provision would have a marked effect.

The regional development and promotion vary according to the natural and socio-economic conditions of the region, and the objectives of the project. In the case of the area under consideration, given the current conditions there and its regional characteristics, the primary objectives of the plan can be summarized into the following two points: "to enlarge the scale of farm management and to establish a district of the agricultural products", and "to improve conditions for settlement in the area by the unified improvement of the infrastructures for agricultural production and living environment". The establishment of the agricultural development plan having a water resources development for a basis, and the establishment of the rural infrastructure

improvement plan corresponding to the improvement of conditions required for the agricultural production , are indispensable measures for the realization of the above-mentioned objectives. In order to improve the effectiveness of the development project and make the best use of the above measures for the regional development and improvement, it will be necessary to select and establish a development plan that takes the following viewpoints into consideration.

- Establishment of a model rural areas that looks to the future

An agricultural development project has been established with the aim of improving the farm management in the San Jacinto and Guadalquivir areas which are major districts for agricultural production in the Valle Central region and are located near the objective areas. The projects in the two areas aim to secure a stable supply of irrigation water through the development of water resources and to improve farm management by enlarging the cropping acreage and improving productivity. The Santa Ana area which is the objective area, forms part of the overall plan with the two areas for the development of the Valle Central region. However, only the objective area aims to incorporate an all-inclusive plan that would result in the improvement of both agricultural production and quality of life in the rural areas. For this reason, the construction of a model rural areas that would reflect the aspirations for a future rural areas in Valle Central should be considered. Its realization would have a exhibition effect on farmers in the region.

- Improvement level

The great expenses for the development, due to the unfavorable quality of soil, climate, and other natural conditions that result from its location, are an impediment to the development of the area. The efficiency factor in regard to the investment for the implementation of the project should, therefore, be given sufficient consideration. In deciding the extent and content of the project, such as the desired extent of developments, the selection of a design year on which to base calculations, and the content of facilities to be provided, similar projects in nearby districts or in the country as a whole should be taken into consideration. In addition to measures that would result in a more efficient utilization of outlays, low-cost construction methods are to be adopted in order to reduce, development costs even further.

- *Manifestation of improvement effect in early stage*

From the viewpoint of present conditions in the area also, it is desired that the effects by improvements would be manifest in